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Electronics

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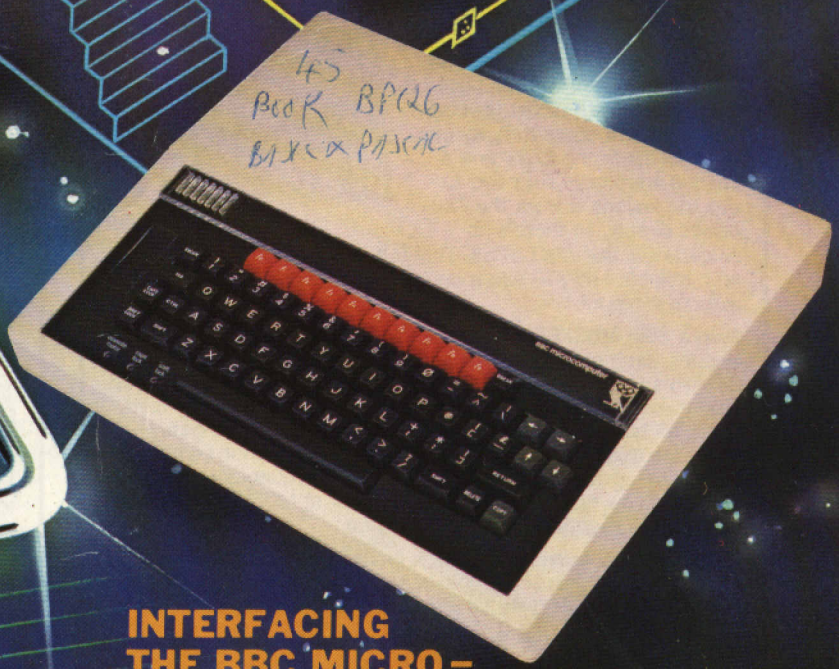

INTERFACING THE BBC MICRO – ALL THE INS AND OUTS EXPLAINED

TWO NEW SHOPS THIS AUTUMN

Coinciding with the publication of this issue of "Electronics" is the opening of our first new store this year. Doors open at 9 a.m. on Tuesday, 16th August, at 8 Oxford Road, Manchester (Tel. 061-236-0281), and we'll be open from 9 to 5.30 Tuesdays to Saturdays from then on.

We're easy to find too; right opposite the BBC between Piccadilly and the University complex, just a few steps from Manchester's Oxford Road Station and about five minutes walk from the city centre. There is excellent parking on meters in the adjacent side roads and we're about five minutes drive straight in from junction 10 on the M63 at the start of the M56.

The big difference with this store is that part of the sales area will be self-service, where you can browse around and choose the parts you want. Counter service will be available as well and upstairs you'll find our computer demonstration area along with hundreds and hundreds of different software packages for Atari, BBC, Commodore 64, Dragon, Sord M5, Spectrum and VIC20.

Our second new store this year takes us to the other end of the country. On November 1st we'll be opening in Southampton, to give us a base in the South of the country. You'll find us at 46-48 Bevois Valley Road (Tel. 0703 25831). The shop has sold electronic components for many years and will start to stock the Maplin range from mid-August, but the full range will not be available until November.

As always, of course, the big event of the year for us is the publication of our new catalogue, and this year it's a massive 480 page book with tons of additional data and pictures. The new catalogue will be on sale at the Electronic Hobbies Fair for just £1, so make sure you get along there as it promises to be a super show. In the pleasant, relaxed atmosphere of the Alexandra Pavilion from October 27th to 30th, we'll be demonstrating lots of our projects and kits and you can see some of the large range of Heathkit products, including the incredible microprocessor controlled robot, Hero 1. We look forward to meeting you there.

The one major difference in the new catalogue is that now you will find everything with its price on the page. And that means in the next issue of this magazine we'll have an extra eleven pages of projects and features. See you then!

Cover illustration by Tony Worsfold

Electronics
THE MAPLIN MAGAZINE

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★ Complements the Syntom and Synwave projects.
★ Makes a metallic chiming sound, similar to bells, gongs etc.
★ Delay variable from 50ms to 5s.

by Robert Penfold

The popular Maplin "Syntom" and "Synwave" projects are capable of synthesising a wide range of percussive sounds, such as drum and hand-clap sounds. The only obvious gap in their "repertoire" is metallic chiming sounds similar to bells, gongs, etc. The "Synchime" unit has been designed to fill this gap, and it has also been designed to match the "Syntom" and "Synwave" units. It can be triggered by tapping the case (or striking a drum on which the unit is mounted) or using a 5 volt positive trigger signal. The envelope shaper has a fast attack time and a decay time which can be varied from about 50 milliseconds to approximately 5 seconds. The other three controls are a straight forward combined volume and on/off type, plus separate frequency controls for the two oscillators. The latter give a wide operating range of about 100Hz to 7kHz so that a wide range of effects can be obtained. The output signal level is up to about 5 volts peak to peak from a low impedance source, which is more than adequate to drive any normal power amplifier.

Block Diagram

A ring modulator and two audio oscillators are used to generate the basic sound signal, as can be seen from the block diagram of Figure 1. A ring modulator is a form of mixer, but it is more like the mixer circuits used in superhet radio receivers than a normal audio mixer. In other words, it heterodynes the two sets of input frequencies to produce sum and difference frequencies at the output. For example, a 1kHz signal at one input would combine with a 5kHz signal at the other input to give output frequencies of 4kHz (5kHz — 1kHz) and 6kHz (5kHz + 1kHz).

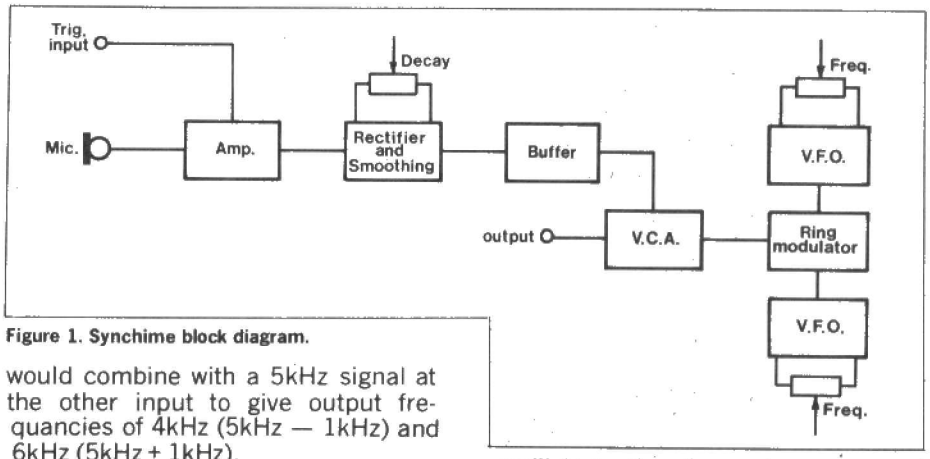


Figure 1. Synchime block diagram.

A ring modulator is a double balanced mixer, which simply means that both of the input signals are balanced or phased out at the output so that only the sum and difference frequencies appear at the output. In practice there is some breakthrough of the input signals at the output, but this is not really of any great significance. The important thing is that the new frequencies generated by the mixing action should be the dominant part of the output signal.

With most instruments the pitch of the sound produced is determined largely by a single dimension, such as the length of a string or a tube. This gives an output spectrum which consists of a fundamental signal plus harmonics of this signal. Instruments which use metal resonators are often two dimensional (plate-like) or three dimensional (bell-like) objects which consequently have more than one fundamental frequency, and mechanically produce a sort of heterodyne effect. A ring modulator fed by two oscillators therefore gives a good electrical analogy of a metallic instrument, and this system generates the desired types of sound.

In order to obtain a realistic percussive sound it is essential to have suitable envelope shaping. A simple fast attack, plus relatively slow decay time is adequate, and this is obtained using an amplifier driving a rectifier and smoothing circuit. When the amplifier receives either a trigger pulse or pulses from the microphone, due to its low output impedance it rapidly charges the capacitor in the smoothing circuit. The discharge rate is controlled by a variable resistor, and this has a value which enables a very long discharge time to be achieved if desired. The output of smoothing circuit is fed to the control input of a V.C.A. which is used to process the output of the ring modulator before it is fed to the output socket.

The Circuit

Figure 2 shows the complete circuit diagram of the "Synchime" unit.

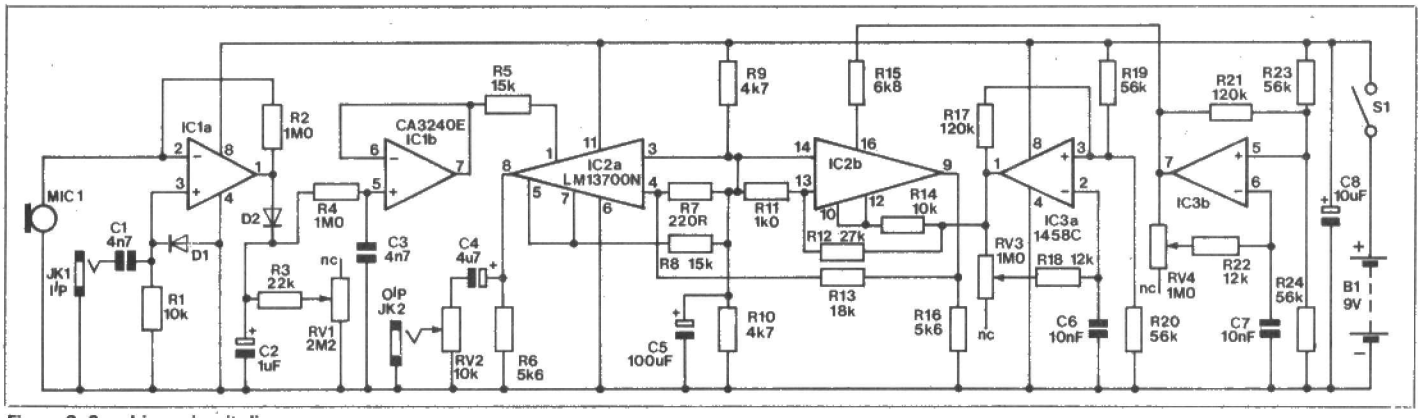
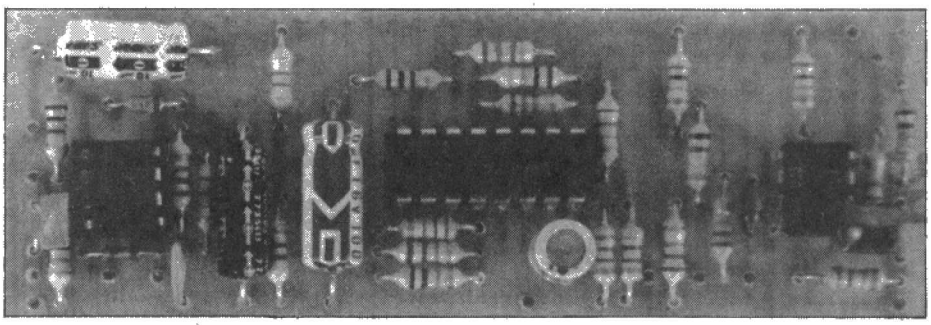


Figure 2. Synchime circuit diagram.



The two audio oscillators are based on the two sections of IC3, and a well known oscillator configuration is used here. The output is a roughly square waveform, and this seems to give good results in the present application due to the strong harmonics which produce a complex signal at the output of the ring modulator.

IC2b is one section of an LM13700N dual transconductance amplifier, and this is the main component of the ring modulator. The output of IC3b is coupled to the amplifier bias input of IC2b via R15. The latter is needed because it is the bias current fed to IC2b that determines its gain, and not the control voltage. Adding R15 in series with the amplifier bias input gives a bias current that is roughly proportional to the applied voltage, and gives the required voltage controlled operation.

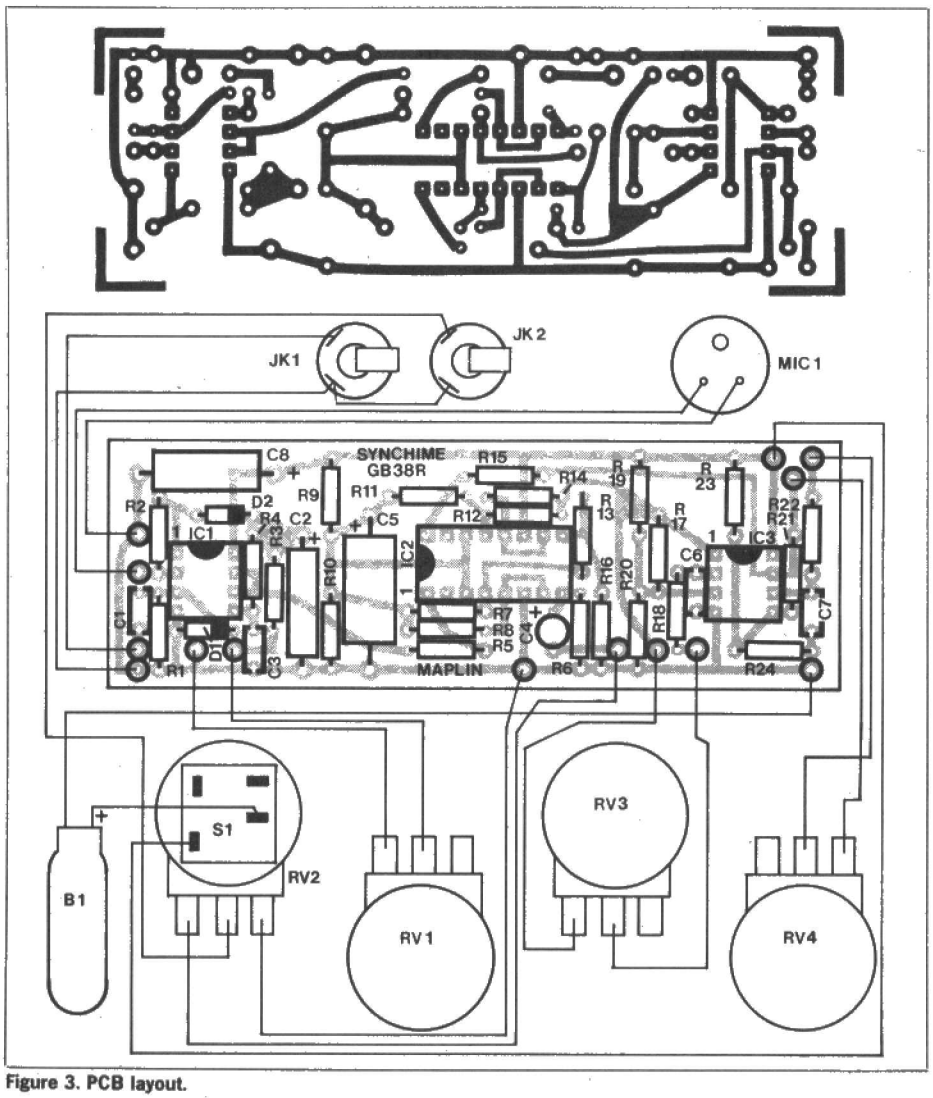


Figure 3. PCB layout.

The output of IC3a is fed to the non-inverting input of IC2b, and it is amplitude modulated by the signal from IC3b to give the heterodyne action and generate the new frequencies at the output. There is little breakthrough of the signal fed to the amplifier bias input and there is no need to add any components to phase out this signal. The same is not true of the signal fed to the inverting input of the modulator, and this does need to be balanced out. This is achieved by including R14 which feeds some of the input signal to the output of the transconductance amplifier. As the signal is inverted through the amplifier this gives the required cancelling, and the value of R14 is chosen to give a high degree of attenuation with the input to R15 at its average level.

Of course, the signal from IC3a is not totally blocked from the output. When the signal to the amplifier bias input is higher than its average level the gain of the transconductance amplifier increases and its output impedance reduces. This increases the signal from the amplifier and decreases the signal obtained via R14 so that the circuit is unbalanced. Similarly, if the signal to the amplifier bias input falls below its average level, the gain of the amplifier reduces, its output impedance rises and the signal obtained by way of R14 increases so that the circuit is again unbalanced. This provides a proper ring modulator action with a signal applied to just one input producing no significant output, but the mixed signal being produced if both inputs are fed with a signal.

R16 is the discrete load resistor for the emitter follower buffer stage at the output of IC2b. From here the signal is coupled by R13 to the input of the V.C.A. This uses the other section of IC2 as a straight forward V.C.A. which has its

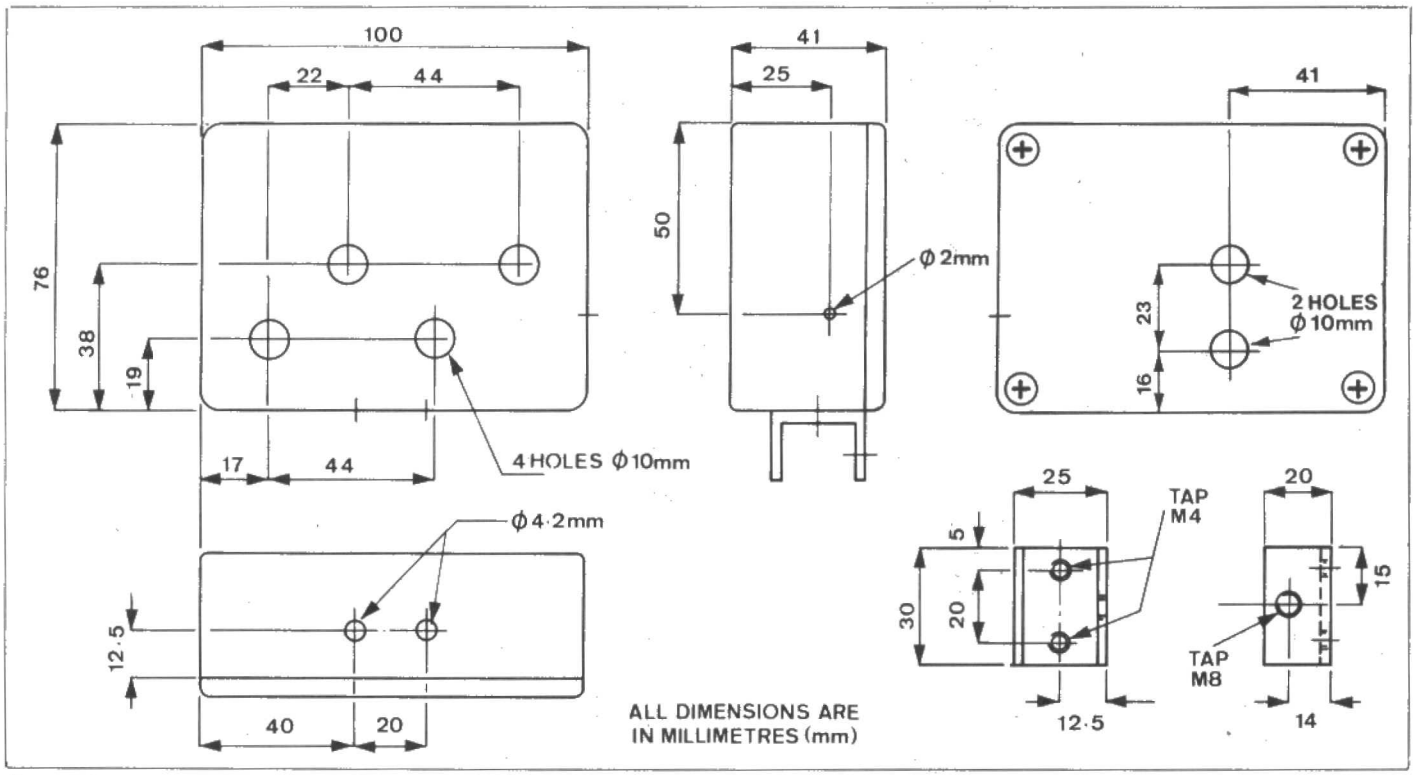


Figure 4. Case drilling details.

output coupled to output socket SK2 through volume control RV2.

IC1a is used as the input amplifier and it has Mic1 directly coupled to its inverting input. This is acceptable as the microphone is a crystal type, and it is actually a crystal earphone which is inexpensive but adequate for this application. R2 has been made quite high in value to give good sensitivity, but if necessary the value of this component could be changed to match the sensitivity of the unit to that of a Syntom or Synwave unit.

R1 biases the non-inverting input of IC1a to the negative supply rail so that the output also assumes this level under quiescent conditions. Negative input half cycles from the microphone drive the output of IC1a positive, but negative half cycles have no effect. The trigger signal is applied to the non-inverting input via C1, and a positive input pulse therefore gives the required positive output from IC1a. C1 is included so that long input pulses are effectively shortened and do not hold the envelope shaper "open".

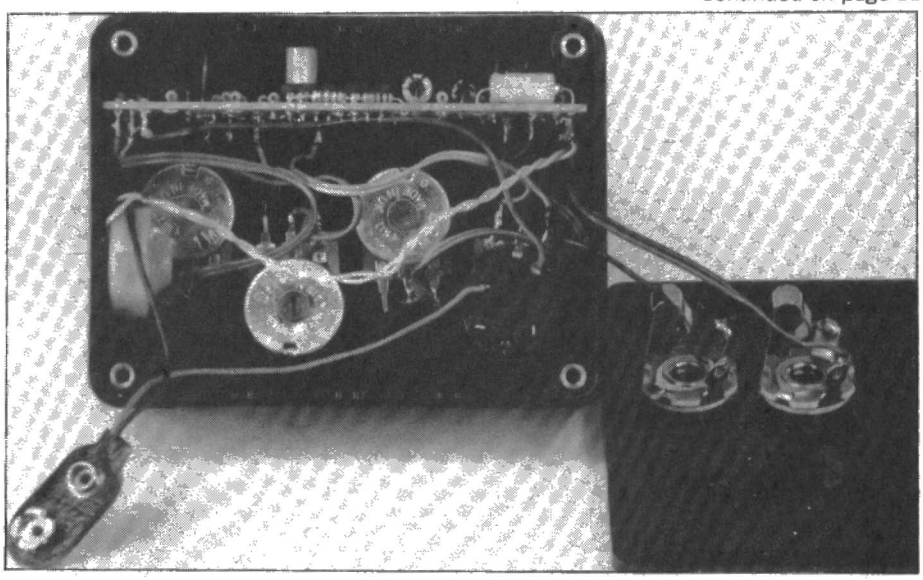
D2 enables IC1A to charge smoothing capacitor C2, but prevents C2 from discharging into IC1a. It can only discharge through R3 and RV1, and RV1 therefore controls the discharge (decay) time of the circuit. R4 and C3 prevent the circuit from having an excessively fast attack time which would cause a loud "click" each time the unit was triggered. IC1b is the buffer amplifier which ensures that the smoothing circuit feeds into a suitably high input impedance. Note that the CA3240E device used in the IC1 position has a class A output stage which enables its output to go within a few millivolts of the negative supply rail so that the V.C.A. is cut off under quiescent conditions. Other dual operational amplifiers such as the 1458C and LF353 cannot produce a low enough output voltage and will not operate properly in this circuit.

Construction

Details of the printed circuit and wiring are shown in Figure 3. The layout of the board is such that crowding of the components occurs in several places, but this is inevitable given the number of components and the size of the board. However, construction of the board is not difficult provided the specified types of capacitor are used and the small components are fitted into place first. IC1 has a PMOS input stage and it should therefore be fitted in an 8 pin DIL socket. The normal MOS handling precautions should be observed when dealing with this device. Veropins are fitted to the board at points where connections to the microphone, battery, and other off-board components will be made. When the board is installed in the case there is insufficient room to take wires over or under the board, and connections from the off-board components have to be made to the underside of the board. Either double sided pins must be used, or single sided pins inserted from the component side of the board must be fitted.

There is only just enough space for all the components inside the case, and the layout is very critical. Figure 4 shows the correct positions for the controls, sockets, and microphone, and it is advisable to follow this as closely and accurately as possible. The microphone, as explained earlier, is actually a crystal earphone. The transparent section of this is unscrewed from the main section and discarded. The screw at the rear of the unit is removed together with the rear cover which will come away with this screw. This screw is then used

Continued on page 11

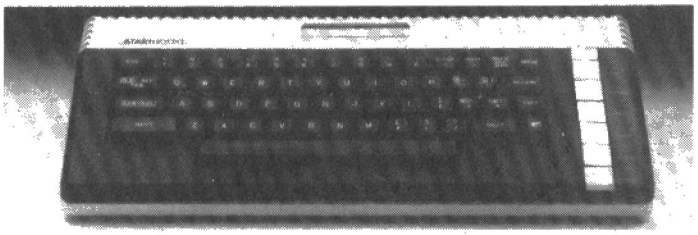


THE NEXT GENERATION

A superb new range of high quality computers from Atari at very competitive prices. The range comprises three new computers similar to the existing 400 and 800, but with the following additional features:

- 24K ROM operating system and BASIC either or both of which may be software switched out.
- Help key to give background information on selected programs.
- 4 special function keys.
- International character set.
- Software compatible with almost all existing software for Atari.
- 11 graphics modes.
- 5 text modes.
- External processor bus for future peripherals including a Z80 CP/M module running CP/M2.2 with its own 64K RAM.
- 256 colours — up to 128 displayable at one time.

Just to set to rest once and for all the popular misconception that Atari computers are just games machines, an expander box will be available in the new year with two RS232C interfaces, a parallel Centronics interface and slots for eight expansion boards. These will include an IBM interface, Z80 interface, 128K RAM disk, Winchester disk controller, modem, 80-column card, real-time clock, voice recognition card and several others. Now let's take a look at this world-beating new range, line by line.



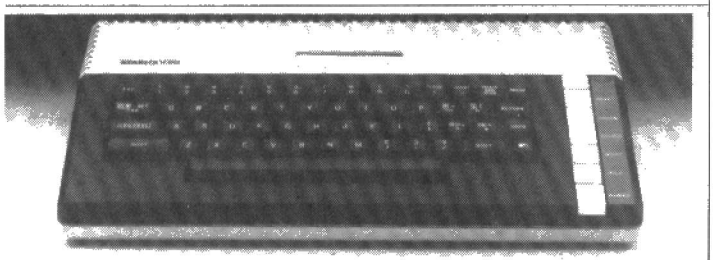
The Atari 600XL Home Computer

Simply — more features for your money.

This stylish new computer replaces the Atari 400, yet features a typewriter-style keyboard like the old 800 model. The single cartridge slot is centrally placed above the keyboard, so program cartridges can be inserted or removed while the computer is on, without disrupting its operation. The computer is supplied with 16K RAM fitted, but a further 48K RAM is also available which simply plugs into the parallel interface port on the computer's back panel to bring the total up to 64K and exactly match the spec of the 800XL. Unlike the American version, the British version is supplied with a socket for a monitor as well as TV. And the price for all that is just amazing.

***†Order As AF77J (Atari 600XL) Price £159.95**

***†Order As AF79L (48K RAM FOR 600XL) Price £99.95**



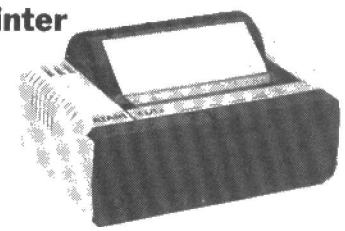
The Atari 800XL Home Computer

Complete with a full complement of 64K RAM.

In a slightly deeper case than the 600XL, the 800XL is a natural replacement for the Atari 800, maintaining all the old features and adding all the new ones described above, yet at a far lower price!

***††Order As AF78K (Atari 800XL) Price £249.95**

Atari 1020 Colour Printer



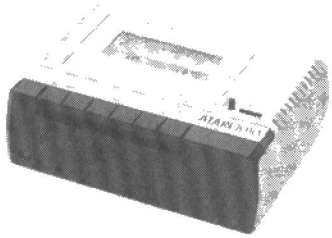
A new plain paper printer to replace the old 822 thermal model. The printer can produce four-colour graphics and text. It can create graphs, charts, artistic designs and comes complete with programs that let you draw on the screen and plot on paper directly, using a joystick and any Atari computer. In standard format mode the printer prints 10 characters per inch at a speed of 10 characters per second. The four-colour print head prints and plots vertically and horizontally and 2 sets of colour pens (red, blue, green and black) are provided.

***†Order As AF83E (1020 Colour Printer) Price £199.95**

****†BK80B (Paper for 1020) Price TBA**

****†BK81C (Rainbow Pen Pack) Price TBA**

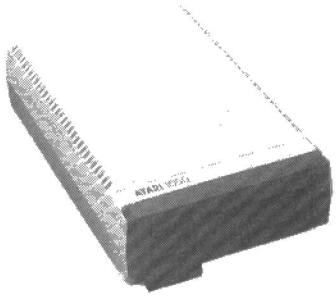
Atari 1010 Program Recorder



Replacing the Atari 410 is the newly styled 1010. It maintains the dual format of the previous recorder, permitting data on one stereo track and audio on the other. An automatic volume control assures perfect record and playback levels and the top-mounted control buttons have a positive touch. Data transmission rate is 600 bits per second giving a capacity of about 100K bytes on a C60 cassette.

***Order As AF80B (Atari 1010 Recorder) Price £49.95**

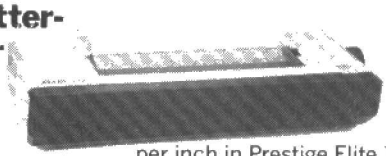
Atari 1050 Disk Drive



This is the new replacement for the 810, and has an improved positive-feel loading mechanism. All new 1050 drives will be supplied with DOS III which permits a higher data packing density so that you can store up to 127K bytes on each side of a disk. You can of course still call a single-density mode which is fully compatible with disks recorded or pre-programmed for the 810, or convert single-density data to the new format. In addition you can of course plug up to 4 of these drives directly onto any Atari computer giving you over half a Megabyte of on-line storage! The attractively designed, sleek new model is about half the height of the 810.

***†Order As AF81C (Atari 1050 Disk Drive) Price £299.95**

Atari 1027 Letter-Quality Printer



This new printer represents a low-cost technological breakthrough in letter-quality printers. It contains a five-wheel printhead that creates fully-formed characters like a daisy-wheel, but at a fraction of the cost. It's ideal for use with a word processor like Atariwriter for example. It prints 12 characters per inch in Prestige Elite 12 face at a speed of 20 characters per second. The printer accepts single sheets of paper and features bi-directional printing and 80 column. There is also an underlining facility.

***†Order As AF82D (1027 Letter Printer) Price £299.95**

****†BK82D (Replacement Ink Roller For 1027) Price TBA**

More New Products

The new Atari product line is swelled by a whole range of new products due for release in November '83 and January '84. They include Atari's new flagship computer, the 1450XLD which in addition to all the features on the 800XL includes 4 programmable keys with 12 preprogrammed functions, and a double-sided dual-density disk drive offering 254K bytes capacity. The price should be under £500!

Also coming soon are a Light Pen, a Graphics Tablet, a new Joystick, an 80-column matrix Printer and a super new Trak-Ball controller that may sell for as little as £30! In addition to all this is the Expansion Box and its range of plug-in cards and the CP/M module described above. We'll have all the latest details in our next issue or for a more detailed specification of this brilliant new range get a copy of our new 1984 catalogue on sale from October 30th.

* Prices are tentative, please check with us before ordering.

** Prices not known at time of going to press.

† Available from mid-September 1983.

†† Available from mid-October 1983.

Please note: The above represents the very latest information from Atari (UK) at the time of going to press, but please check any specific point with us before ordering.

Rewiring Your House

by Geoffrey Burdett

The modern home electrical installation consists of a number of circuits of various current ratings to meet the required total expected load in kilowatts. The current rating of each circuit is the maximum likely load demand which in aggregate gives the total maximum current demand on the installation. Most circuits originate at a combined mainswitch and fuse distribution board, termed a consumer unit.

The fuse distribution section of the consumer unit comprises a number of fuseways, one for each circuit. Although traditionally termed fuseways, in many instances miniature circuit breakers (mcb's) are fitted into the fuseways instead of fuse units, these generally being superior to the fuses they replace.

Although there are, or should be initially, at least the number of fuseways in the unit to meet circuit requirements plus others to add circuits as they are needed over the years this is often not the case.

Where only one circuit is added, it is common practice to fit what is termed a mainswitch and fuse unit, or switchfuse unit which is really a one-way consumer unit.

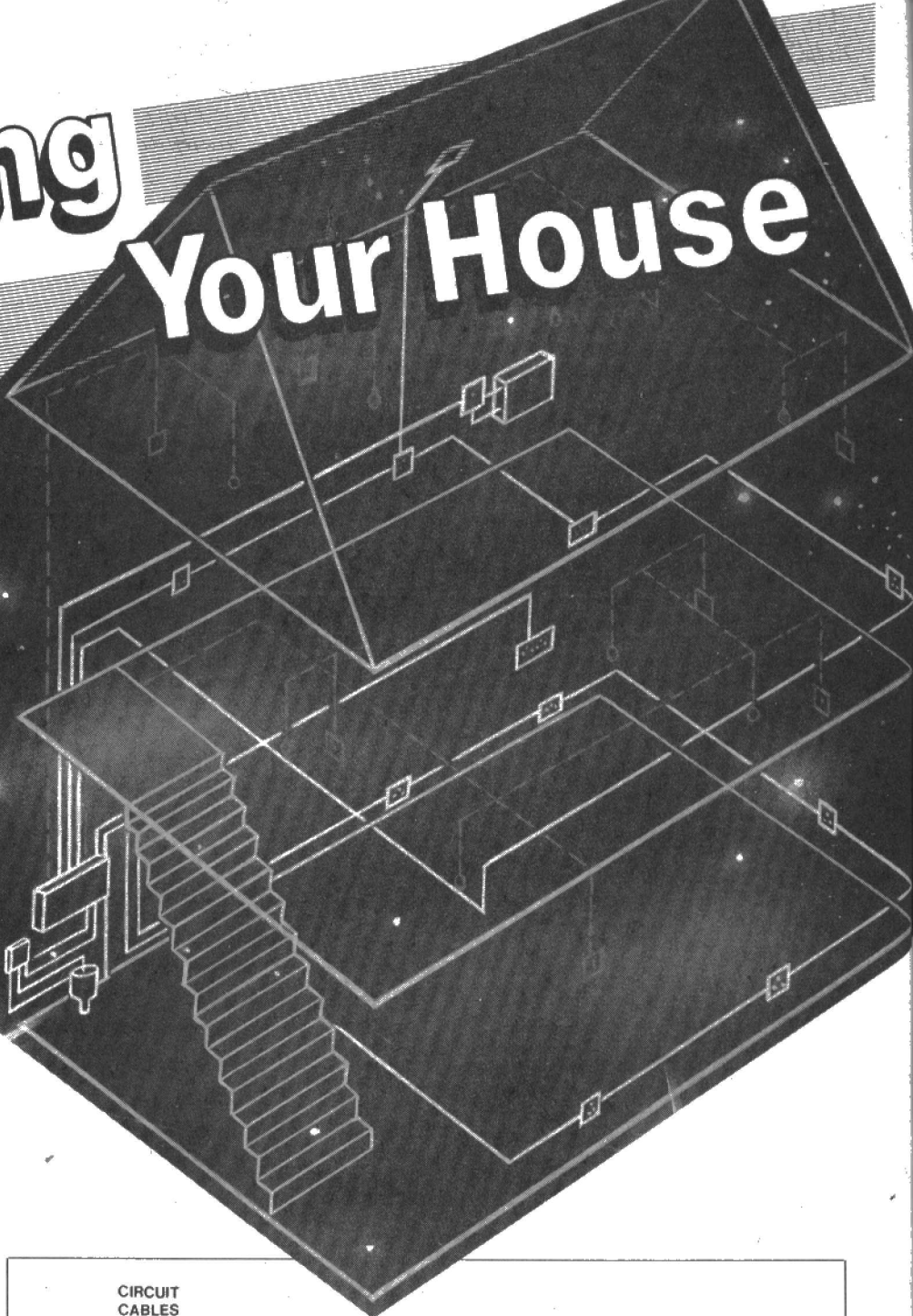
Such practice lacks foresight, and although only one circuit is added at the time it is better to allow for at least another circuit which means fitting a multi-way consumer unit. Whether a switchfuse unit or a multi-way consumer unit, this, with the existing consumer unit, is connected separately to the mains by the electricity board, usually via a service connector box.

Some installations have yet another consumer unit, for off-peak storage heating and water heating, time controlled by a time switch so that the circuits and appliances are energised only during the off peak period eg. about 7 hours overnight when electricity is supplied at about half price. See tariffs.

Circuit cables

Most houses are now wired in pvc flat sheathed cable. The cable termed twin and earth has two insulated current carrying conductors, one red, the other black, and an uninsulated copper earth conductor now called the circuit protective conductor (cpc) and formerly the earth continuity conductor (ecc), because it is electrically continuous throughout the installation and terminated at the central earthing point, the earth electrode. In some parts of an installation 3-core plus earth flat pvc sheathed cable is used, usually in switching circuits containing more than one switch for the one light or for different lights in the same area. eg 2-gang, 3-gang assembly etc.

The core colours of 3-core and earth cable are red, yellow, and blue respectively plus the uninsulated earth conductor. The colours have no significance in home wiring but represent the three colours of the phases of a 3-phase electricity supply system. When used on single phase circuits



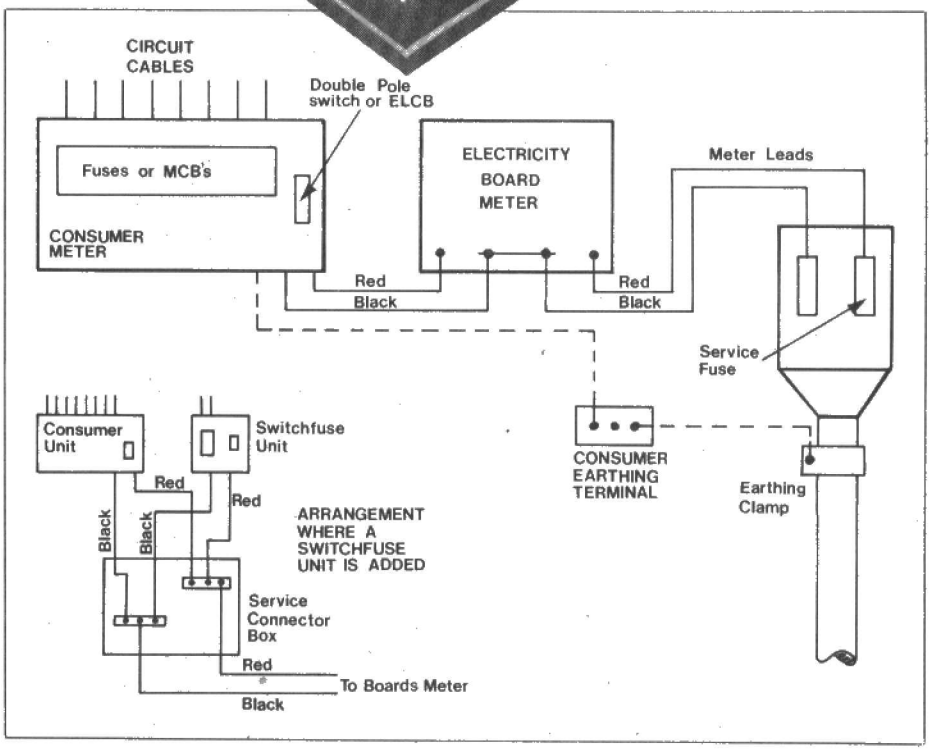


Figure 1. Arrangement at mains supply.

in the home for single pole switching the conductor ends should be enclosed in red sleeving or insulation tape as they are all live conductors.

Circuit cables are sold normally in 50m and 100m reels though they can be bought in shorter cut lengths where a limited amount only is required, this usually being the case with 3-core and earth cable and all the larger sizes of cables used in the home installation. Some homes are wired throughout in plastic conduit using non-sheathed pvc insulated cables in various colours. The cables are single-core and the colours are red, black and green/yellow striped, respectively.

The red is used for the live conductors, the black mainly for the neutral but is sometimes used as a live, suitably identified with red sleeving. The green/yellow conductor is the earth conductor.

Plastic conduit is also used in some twin & earth and 3-core & earth wiring, but as the cables are sheathed the conduit does not have to be continuous. It is used at switch drops and other vertical drops as well as in horizontal cable runs. Another form of enclosure for sheathed cables is plastic mini-trunking run vertically or horizontally on walls and ceilings.

Sizes of cables

The size of a cable is given as the cross section area in mm² of its current carrying conductor, the earth conductor in such composite cables usually being smaller since it carries current only to clear a fault. Earth conductors run independently are sized according to their cross section area in mm².

Circuit cables each have a specific size of current carrying conductor, the size determining the maximum current it is designed to carry without further rise in temperature. Possible voltage drop on long runs is also a factor considered when choosing a cable. The cable sizes used in home wiring circuits range from 1mm² to 10mm², with larger sizes for the connection of the consumer unit to the meter, these being termed meter leads or meter bights.

The 1.0mm² cable is used for lighting circuits, the 10mm² cable for cooker circuit cables. The intermediate sizes of cables for other circuits. See table 1 for the current ratings.

Circuit wiring accessories

In addition to the cables there are various components used in circuit wiring. The mounting box is among the most important wiring accessories, though often omitted. It is used for mounting socket outlets switches, fused connection units and a host of other accessories, these having open backs. The function of the box, in addition to being a ready mount for the accessory, is to enclose the unsheathed ends of cables, flex and connectors where used, in a non-combustible chamber.

There are two principal types of mounting box: moulded plastic and metal. The moulded plastic box is for mounting the accessory on surfaces and the metal box is for flush mounting the accessory, the box being sunk into the plaster or wall.

The boxes are of various sizes and depths. The most used box is the one-gang for mounting a single one-gang accessory. It is square in shape, approximately 87 x 87mm, the faceplate of the switch or other accessory being the same size. The metal box is slightly smaller at 86 x 86mm so that the accessory faceplate overlaps the box and covers the gap in the plaster.

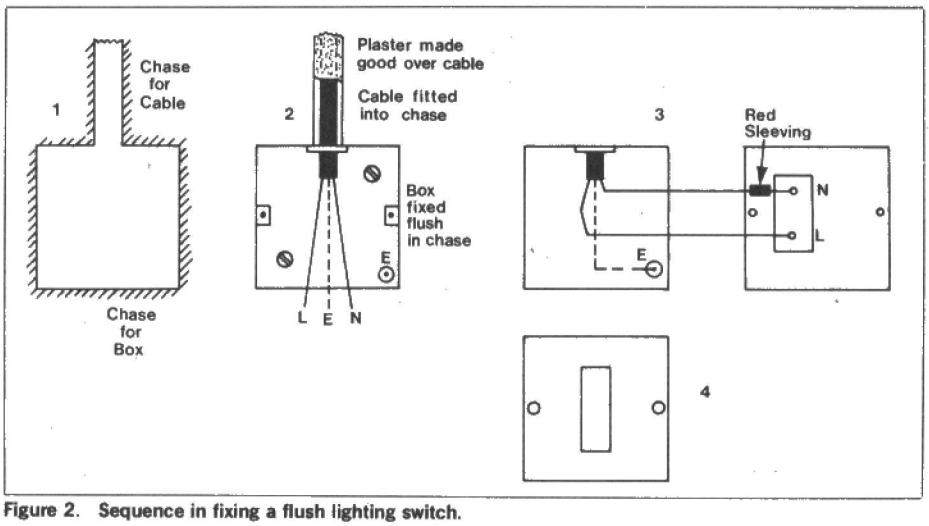


Figure 2. Sequence in fixing a flush lighting switch.

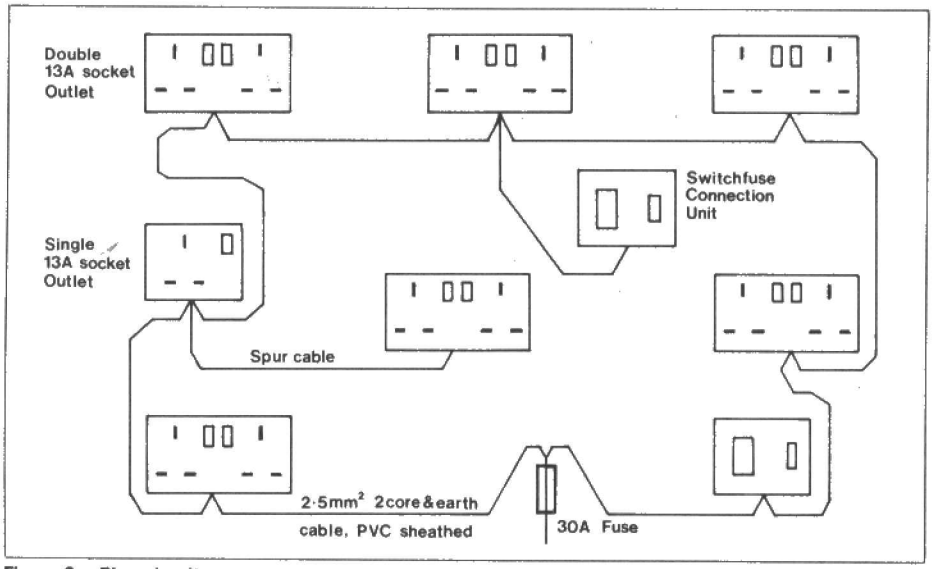


Figure 3. Ring circuit.

Depth of boxes

The boxes for lighting switches are plaster depth 16mm deep, and the plastic box 17mm.

For socket outlets the standard box has a depth of 25mm and deeper boxes where needed depending upon the accessory and the room needed in the box for cable connections. All have two or more screwed lugs for fixing the accessory, these being tapped M3.5 metric. Some lugs are adjustable for levelling the accessory after the box is fixed.

Socket outlets and plateswitches are actually flush fitting components, although surface mounted or flush mounted according to the type of box. Surface sockets are entirely different. They are self contained, and usually have an enclosed back for direct mounting on a suitable surface, the sheathed cable passing right into the accessory. Some versions are, however, mounted on a slim pattress block. There are also surface type switches, these usually being metalclad and sold complete with metal surface boxes. Whatever the type of box or accessory it is essential that the pvc

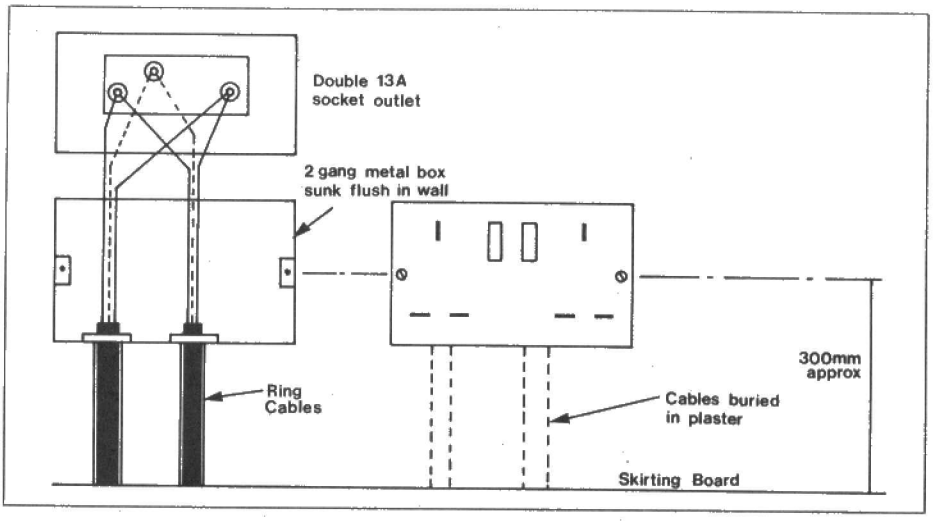


Figure 4. Fixing and connecting a ring socket outlet on the wall above a skirting board.

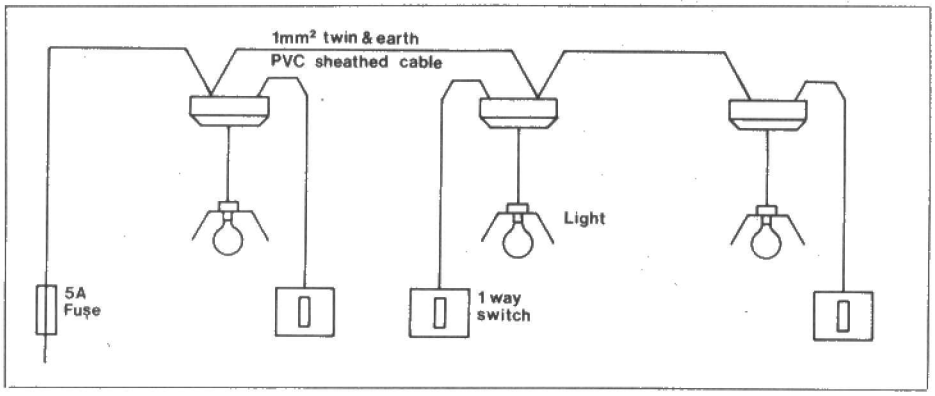


Figure 5. Lighting circuit wired on the loop-in system.

cable sheathing terminates within the accessory or its box.

The modern ceiling rose has no box and does not need one. It has an integral backplate, enabling it to be fixed direct to the surface of the ceiling. Thin plastic sections are knocked out of the backplate into which the sheathed cables are passed. Some batten lampholders and other ceiling fittings have an integral backplate, and need no box. However, most of the special pendant fittings do require a mounting box. This is a circular conduit box termed a BESA box, having a back outlet and fitted flush into the ceiling to support the ceiling plate and the fitting. Two screwed lugs are M4 metric. The box can be plastic, but where it is to support a fitting in excess of 3kg a metal box is necessary. The box is fixed to timber between joists, with a hole drilled to take the box outlet.

Most wall lights, as well as spotlights, also need to be mounted on boxes, to join the circuit wires to the flex wires and to contain the cable connector.

Lighting switches

The modern lighting switches are termed plate switches because of their faceplate, usually moulded plastic but sometimes metal. Most fit a one-gang slim or plaster depth box. The switch assembly can be a single switch, either 1-way, 2-way or intermediate, or it can comprise two or three switches in the one gang, these would all be 2-way switches which can be used for either one-way or two-way. Where four, five or six switches are required in the one position, a 2-gang faceplate and a 2-gang box are used.

Other switches

There is a whole range of switches used for other circuits including 20A double-pole, these requiring a deeper box. Cord operated switches used in the bathroom and bedroom are also made in one-way, two-way and double pole versions with and without neon indicator.

Socket outlets

The modern socket outlet used in the home installation is the 13A with fused plug having square pins, and has largely replaced the old round-pin 2- and 3-pin plugs and sockets of 15A, 5A and 2A current rating. As already explained, most sockets are of the flush type, either switched or non-switched, with or without neon indicator, in single and double versions.

Junction boxes

Junction or joint boxes used in home wiring systems are plastic, usually circular and have three or four terminals or banks of terminals. They are made in current ratings of 5A, 20A and 30A.

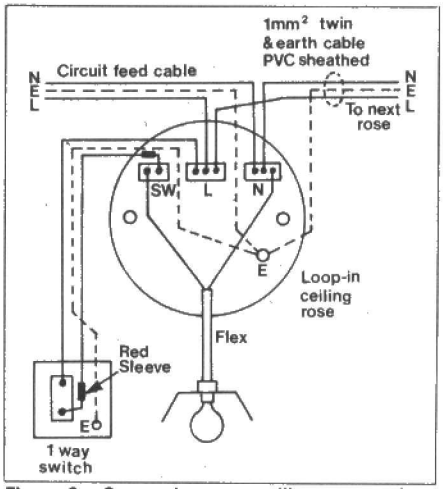


Figure 6. Connections at a ceiling rose on the loop-in system.

The ring circuit

A ring circuit, or ring final circuit to give it its official title, consists of a pvc flat sheathed cable starting at a 30A fuseway or mcb in the consumer unit, and runs throughout the various rooms, finally returning to the same fuseway terminals, forming a complete loop or ring, the connections being made at either the terminals of a ring socket or at a joint box.

Why a ring?

The ring circuit was designed in 1943/44 as a post war measure to enable dwellings to be equipped with an ample supply of socket outlets with the minimum of cable, when copper was in short supply. Before the advent of the ring a 15A socket outlet had to be supplied from a separate circuit, which meant 6 circuits for 6 15A socket outlets. However, abuse of the system over the years meant that sockets had been added to the original circuits, with subsequent danger from overload on the old wiring.

Therefore a circuit was designed to allow a number of power sockets to be supplied from a single circuit, which would save cable and require only one fuseway in the consumer unit, or fuseboard. The alternative was a radial circuit, which to supply a number of 13A socket outlets would mean a very heavy and costly cable. The cable would have to be of 30A current rating and its conductors would be too large for looping in and out of terminals of socket outlets. Ultimately the circuit in the form of a ring was devised using cable half the current rating at 15Amps. For about the same cost the cable supplying the ring would be nearly twice the length, cover a wider area, and be able to supply more socket outlets than a single run of cable.

Since each socket outlet connected to the ring cable would in effect be supplied by two cables (outgoing and incoming), this gave the circuit a current rating of 30A to match the circuit fuse or mcb. The size of the circuit cable was 7/.029 imperial which had a current rating of 15 amps, but was uprated to 21 amps, as is its metric equivalent 2.5mm² now used to wire ring circuits.

Local fusing at each outlet was made necessary because the circuit fuse is 30A and requires anything up to 60 amps to blow. The local fuse is in the plug, so that it protects the appliance and flex connected to it against short circuit current. The current rating (maximum) of a plug fuse is 13A which is the equivalent of a little over 3000 watts. The rectangular shape of the plug pins was chosen so that it could not be plugged into any other existing socket nor could any other plug be plugged into the 13A socket outlet.

The number of 13A outlets (sockets and fused connection units) which may be supplied from any one ring circuit is unlimited but the area in which the outlets are fixed must nox exceed 100m². The logic is that adding sockets within a given area does not itself increase the load or current demand but to increase the area is likely to, so far as space heaters are concerned.

Spurs

As mentioned, a spur is a cable branching off the ring cable at a convenient point, which can be the terminals of a ring socket or a 30A joint box inserted into the ring cable. Its principal purpose is to supply a socket outlet or a fixed appliance via a fused connection unit off the main route of the ring cable. This arrangement saves cable, but as it is a single length of 2.5mm² having a current rating of only 21 amps it may supply only one outlet. This can be either a single or a double socket or a fused connection unit. The number of spurs on a ring circuit must

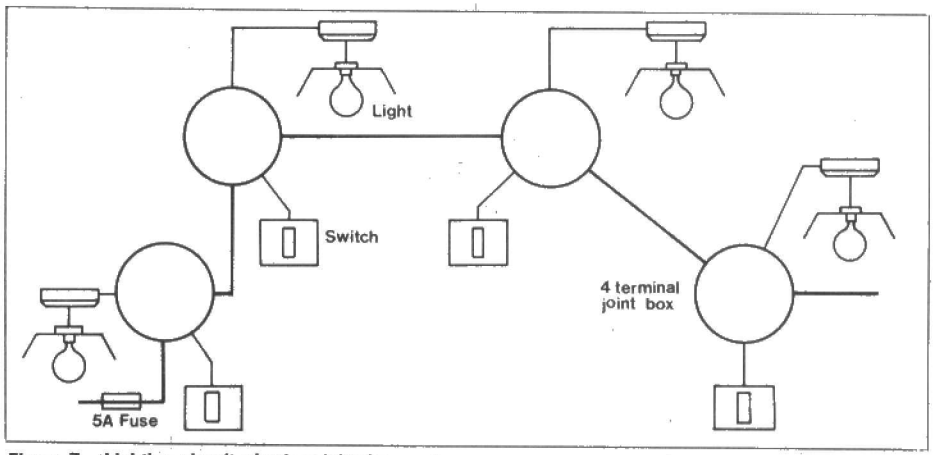


Figure 7. Lighting circuit wired on joint box system.

not exceed the number of socket outlets connected to the ring cable. Chiefly, spurs should be limited mainly for future extensions rather than to install initially, except where significant saving in cable can result.

Lighting circuits

A lighting circuit is a radial circuit, which means that the circuit cable terminates at the last light on the circuit and does not return to the fuseway to form a ring.

A ring is not necessary, since the cable is smaller, and can extend throughout the house if necessary, and the number of lighting points will still be consistent with the current rating of the circuit fuse or mcb.

There are two principal methods of wiring lighting circuits, or rather lighting points, and either or both methods can be used on any one circuit. These are the loop-in and the joint box methods.

Loop-in method

With the loop-in method the lighting circuit cable is run from a 5A fuseway in the consumer unit to each of the lighting points, starting at the nearest, looping out to the next, and so on until the last on the circuit, where the cable terminates.

Then, from each lighting point, a length of the same cable is run to the respective switch position, usually on the wall of the same room or area, eg hall or landing, and in some instances, such as in the bathroom, to a ceiling switch next to the access door. All the cable joints are made in the ceiling rose which also serves as a joint box with ready access in the same room.

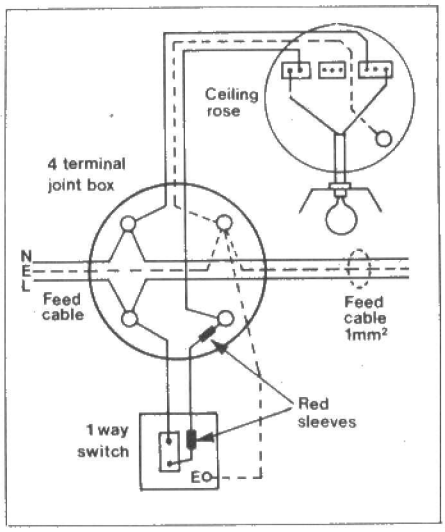


Figure 8. Joint box system.

Joint box method

With the joint box method the lighting circuit cable is run from the 5A fuseway to a series of 4-terminal 15A joint boxes, one for each light, and its switch situated in a convenient position between each light and its switch.

Then from a joint box two additional cables are run, one to the light the other to the switch, making a total of four cables, two feed cables plus the light and switch cables, except at the last joint box where there is only one feed cable. All joints are made in the joint boxes, which being situated in the ceiling voids or roof space are comparatively inaccessible, which is the main disadvantage of the joint box method. The main advantage is that less cable is normally used.

Mixed method

Although there are two methods, both can be applied to any one circuit, some lights being wired on the loop-in system, usually where ceiling roses are used. On other lights with no loop-in facilities, such as wall lights and some ceiling fittings and pendants, the joint box system is used with only one cable going to the light.

In rewiring the loop-in system is usually employed, since the new cables are run under the floorboards with the minimum disturbance and there is no need to allow for the fixing of joint boxes. Where the circuit cables are run in the roof space for the upstairs lighting the joint box method is often used, with the joint boxes fixed between joists.

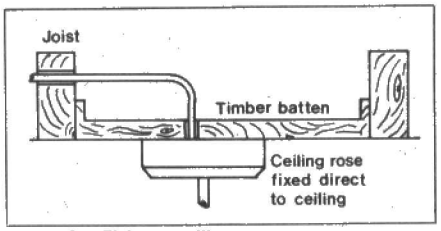


Figure 9. Fixing a ceiling rose.

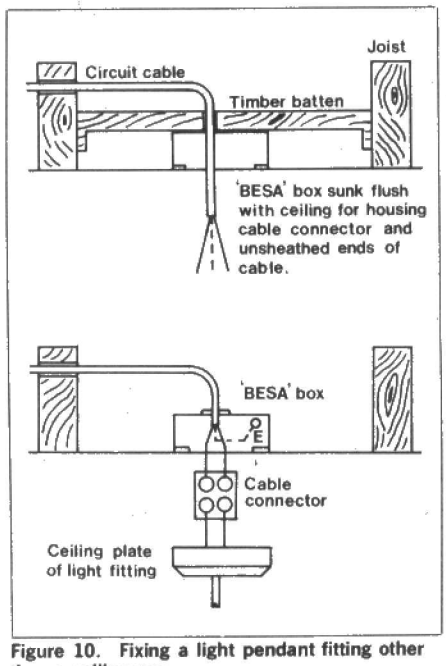


Figure 10. Fixing a light pendant fitting other than a ceiling rose.

Number of lights per circuit

A lighting circuit of 5A is on a 240V electricity supply equal to 1200 watts. This is the maximum which should be connected to the circuit. However regulations stipulate that a light containing a tungsten filament bulb is assessed at 100 Watts for any bulb, up to and including 100 Watts. Bulbs of higher wattage are assessed at the actual wattage. 12 bulbs at 100 watts each total 1200 watts, which is the maximum permitted. This means that the circuit may serve twelve lampholders, provided none contain bulbs of higher wattage than 100W. Where there are higher wattage bulbs the number of lampholders are reduced proportionately. With one or more 2- and 3-light fittings plus higher wattage bulbs the number of lights on a circuit should definitely not exceed eight, and preferably no more than six, so that the area affected by a fuse blowing is limited; this also allows for future additions of one or more lights on a circuit. A house of 3- or 4-bedrooms usually requires two lighting circuits but where wall lights and spotlights are included the number will be more.

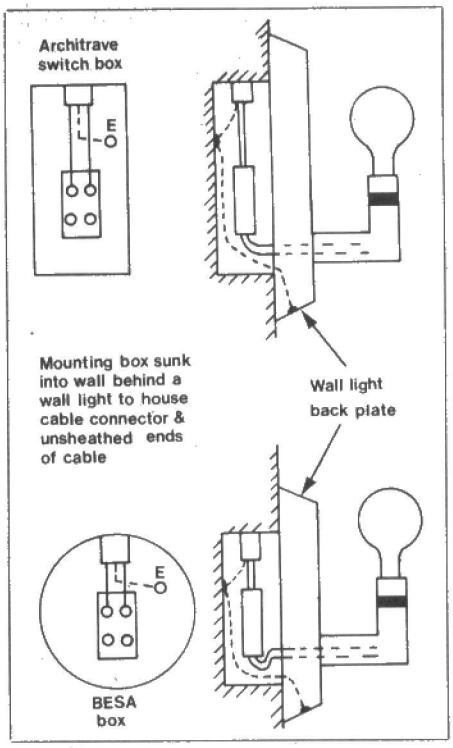

Architrave switch box
L
E
Mounting box sunk into wall behind a wall light to house cable connector & unsheathed ends of cable
Wall light back plate
BESA box

Figure 11. Mounting wall lights.

Fixed lighting, especially spotlights, can be supplied from a ring circuit via a fused connection unit fitted with a 3A fuse. Cable used for a lighting circuit is, as already explained, 1.0mm² twin & earth pvc sheathed with some sections wired in 3-core and earth pvc sheathed cable.

Installing lighting fittings

The simplest lighting fitting is the plain pendant comprising ceiling rose, flex and pendant lampholder. The ceiling rose of the wired pendant is connected to the circuit cables and fitted direct to the ceiling, with wood fixing between the joists to support it. See figure 9 for connections. Batten lampholders and some enclosed lighting fittings are similarly connected, but as already explained a special pendant having a ceiling plate is connected to a circular box fixed flush with the ceiling. The circuit wires are connected to the flex using cable connectors housed in the box. See figure 10.

Wall lights are fixed either to a round box or are mounted over an architrave switch box and fixed direct to the wall. See figure 11.

Fixing switches

A wall switch is fixed to a box mounted on the wall at a height of about 1.4m above floor level. For surface mounting a plastic box is used. This is fixed to the wall by two No.8 wood screws in holes drilled and plugged in the wall. A section of thin plastic is knocked out of the edge of the box and the cable threaded through. The end of the sheathing within the box is stripped off, and about 10mm of insulation from the end of each of the two insulated conductors. A piece of red sleeving or red pvc insulation tape is fitted over the end of the black wire, and the two conductors are connected to the two terminals of the one-way switch. The bared end of the earth conductor is enclosed in green yellow striped pvc sleeving and the conductor is connected to the earth terminal of the box. If a 2-way switch is used one conductor is connected to the common terminal of the switch, the other to the L2 terminal, and the switch fixed to the box with the Top on the faceplate at the top so that the rocker will be down to switch the light on.

For flush mounting the plastic box is fitted into a plaster depth chase cut into the plaster and, using No.8 wood screws, fixed to the wall in the two drilled and plugged fixing holes. For a cord operated ceiling switch the cable is passed through a removed section of thin plastic in the backplate, the ends prepared and the black conductor with red sleeving connected to the switch terminals and the sleeved earth terminal connected to the earth terminal on the backplate.

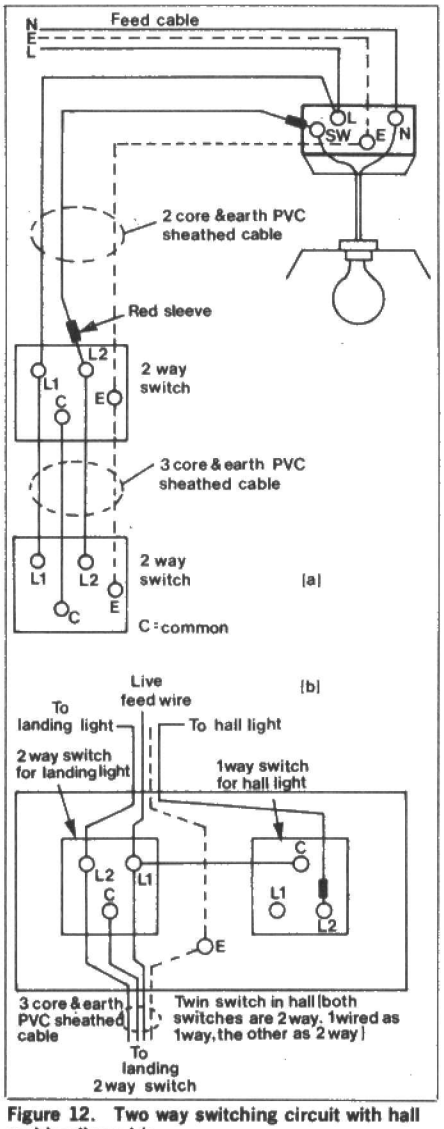


Figure 12. Two way switching circuit with hall and landing wiring.

Two-way switching

Where a light is to be controlled by two switches in different positions a 3-core and earth cable is run from the first switch position to the second switch position and a 2-way switch fixed at each. The connections at each switch are shown in figure 12.

Intermediate switching

Where a light is to be controlled by three or more switches in different positions intermediate switching is used. This is a 2-way switching circuit with a 2-way switch at each end and one or more switches fixed in intermediate positions between the two 2-way switches. One intermediate switch is needed for each extra switch position. An intermediate switch is an ordinary plate switch of the rocker type, but has four terminals instead of the two of a 1-way switch and three of a 2-way switch.

The 3-core and earth cable running between the two 2-way switches is cut at each intermediate switch and the yellow and blue wires connected to the terminals as shown in figure 13. The red wire running from the common terminal of one 2-way switch to the common terminal of the other 2-way switch is not connected to an intermediate switch, but because the cable is cut the conductor is jointed in the mounting box of the intermediate switch so that it is continuous from one 2-way switch to the other.

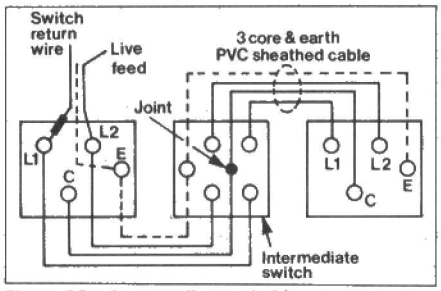


Figure 13. Intermediate switching.

Dimmer switches

Where a light is to be controlled by a dimmer switch instead of a rocker switch the dimmer switch replaces the rocker switch without any need for modification in the wiring. Most dimmer switches fit the shallow or plaster depth switch. They are made in one and two-gang assemblies, to fit a one-gang box and control more than one light.

Where the light is fluorescent a dimmer switch cannot be used,though there are special dimmers and fluorescent fittings that can be used, but an extra switch wire has to be run from the switch to the fluorescent lighting fitting.

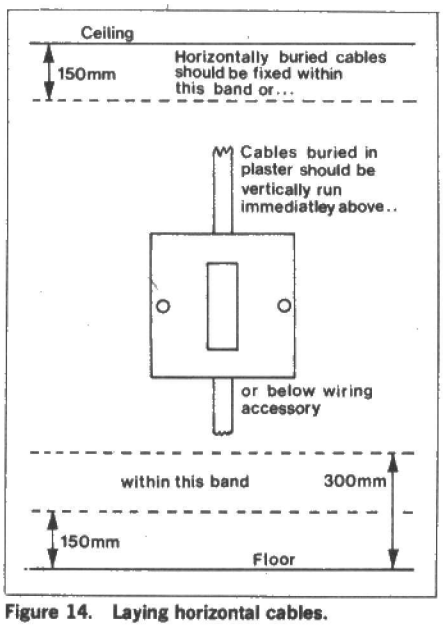


Figure 14. Laying horizontal cables.

In a roof space where polystyrene granules are used for heat insulation pvc sheathed cables must be situated where they do not come into contact with them, as the pvc is adversely affected by it. If it is not possible to avoid the insulation the cables should be enclosed in plastic conduit. Generally cables in the roof space should be situated away from walkways and the cold water storage cistern where they are likely to be disturbed.

Running circuit cables

The various circuit cables are normally run in the void between the ceiling and floorboards above the ground floor of a 2-storey house. These cables serve the lighting points and switches in the room below. Ring circuit cables supply socket outlets in the first floor rooms, and cables to an immersion heater and other apparatus are also run in this void. In the roof space are mainly lighting cables feeding the lights and switches in the rooms below, though the cable to the shower in the bathroom is sometimes run in the roofspace to a ceiling switch in the bathroom.

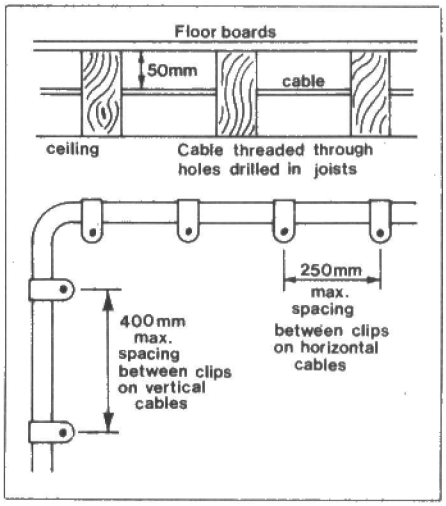

Floor boards
50mm
cable
ceiling
Cable threaded through holes drilled in joists
250mm max. spacing between clips on horizontal cables
400mm max. spacing between clips on vertical cables

Figure 15. Fixing cables.

On the ground floor cables are run in the void below the floorboards where it is a suspension floor, but if the floor is solid cables may be run in conduits before the screed is laid, otherwise they are run behind skirting boards. PVC sheathed cable may in fact be run anywhere along the house structure, fixed to the surface or buried in the plaster without the need for protection from the risk of mechanical damage.

Cables clipped to the surface must have fixings not more than 250mm apart for horizontal runs and not more than 400mm apart for vertical runs. Where cables are buried in the wall they should as far as practicable be run vertically exactly above or below the switch or socket outlet they feed so that anyone later fixing shelves will know where to expect them. Where horizontal buried cables cannot be avoided they should be run in a band 150mm from the ceiling or between 150mm and 300mm above floor level. Where cables are run under floors and cross joists they must be threaded through holes drilled in the joists not less than 50mm below the tops of the joists.

It is neither necessary nor desirable to enclose pvc sheathed cables in conduit where buried in the wall since they are unaffected by plaster, and the extra chopping away can damage the wall structure. In houses under construction it is usual to enclose them so they stay in place and are not damaged by the plasterer's float during plastering.

Permission to wire

No permission is required in Britain to carry out home electrical installation work, though where the house is rented permission may be necessary from the owner. Neither electricity boards nor local authorities or any other official body has any jurisdiction in respect of wiring. The work should however conform to the IEE Wiring Regulations published by the Institution of Electrical Engineers and recognised as a code of good wiring practice by all official bodies, including electricity boards and government departments. The regulations,

contrary to popular belief, are not statutory, and an electricity board has no powers to refuse connection to its mains of an installation, or parts of it, which do not strictly conform to the current IEE wiring regulations, but a board can and will refuse connection to its mains of any installation which is dangerous and as such does not conform to the Electricity Supply Regulations. These are statutory and are quoted in the application form signed by a consumer when requiring a supply of electricity.

An installation conforming to IEE Wiring Regulations is deemed to satisfy the requirements of the Electricity Supply Regulations and the electricity board must connect it to the mains. In these circumstances the board must connect the installation, whether carried out by a recognised contractor or by the householder himself.

From a contractor the board requires a test certificate, and may waive its own test and inspection. The householder who is unable to complete a test certificate can expect the board to test the installation through they are not obliged to do so. The test is at the option of the electricity board and is mainly to satisfy them that the installation will not adversely affect the supply to other consumers. It is important to note that good workmanship using correct material is necessary to conform to the regulations.

Electricity tariffs

A tariff is the means by which an electricity board calculate the amount to charge a consumer for electricity and the service provided. Basically, all tariffs consist of a fixed quarterly charge plus a charge for each unit of electricity consumed. Most domestic tariffs are of this type, though where a lot of electricity is consumed during off-peak times the charge for the electricity may be reduced, or even halved. A popular off-peak domestic tariff is the Economy 7 which provides electricity over a 7-hour night period at a cheaper rate.

Electricity consumed is registered on a 2-rate meter, and all electricity consumed during the 7-hour period is cheaper, whereas in some former off-peak tariffs only the electricity consumed by storage heaters qualified for the cheaper rate.

Even though the cheap rate now applies to all electricity consumed during the off peak period it is not usually financially beneficial to adopt the tariff, because the day time rate is higher than the standard rate per unit on the ordinary tariff. It is therefore advisable to have the tariff temporarily for at least two quarters (one summer the other winter) so that a comparison may be made.

*These current ratings apply where the cables are clipped direct to the surface. Ratings are lower for enclosed cables and some other situations, but are all suitable for the circuits specified.

Circuits	Fuses	Colours
Lighting	5A	White
Ring	30A	Red
Immersion heater	15A	Blue
Storage heater and 20A Radial Circuit	20A	Yellow

Current ratings of house wiring cables

The various cables used in house wiring with their sizes, current ratings, and the principal circuits in which they are used are as follows:

Cable size mm²	Current rating* amps	circuits
1.0	16	lighting
1.5	20	lighting and 15A single socket circuits
2.5	28	ring circuits and 20A radial circuits
4.0	36	radial circuits (30A)
6.0	46	cooker circuits, shower unit circuits
10	64	cooker circuits
16	85	meter leads
25	108	meter leads

SYNCHIME *Continued from page 4*

to mount the microphone inside the case.

The printed circuit board fits into the top set of horizontal mounting rails in the case with the component side facing upwards. it will probably be necessary to angle C7 slightly inwards so that it fits under one of the corner mounting pillars of the case. Before finally fitting the board in place complete all the point-to-point style wiring. There is space for the PP3 size battery to fit between the sockets and the microphone, and a piece of foam material can be used to wedge this firmly in place.

Testing

With SK2 coupled to an amplifier and the volume control advanced, tapping the unit should give an output, and using RV1 it should be possible to control the duration of each burst of output signal. The two pitch controls can be a little confusing at first, and it has to be remembered that the main output signals are the sum and difference signals produced by the fundamental frequencies of the two oscillators. The fundamental frequencies themselves appear at the output at a very low level, and might not be apparent at all.

In practice this means that quite a low pitch can be obtained if both pitch controls are set for a high output frequency, since the difference frequency might then be just a few tens of Hertz. With a little experimentation you should soon discover the types of sound that are produced at various control settings. At most settings of the pitch controls the output sounds quite discordant, but with the two oscillators set some musical interval apart, normal chime type sounds will be obtained. Good effects can be obtained with the two oscillators just fractionally off-tune, so that a low frequency beat not is obtained. At most settings of the frequency controls the output signal contains a wide range of frequencies, and filtering the output signal can expand the range of effects that can be obtained.

SYNCHIME PARTS LIST

Resistors — All 0.4W 1% Metal Film

R1,14	10k	2 off	(M10K)
R2,4	1M	2 off	(M1M)
R3	22k		(M22K)
R5,8	15k	2 off	(M15K)
R6,16	5k6	2 off	(M5K6)
R7	220R		(M220R)
R9,10	4k7	2 off	(M4K7)
R11	1k		(M1K)
R12	27k		(M27K)
R13	18k		(M18K)
R15	6k8		(M6K8)
R17,21	120k	2 off	(M120K)
R18,22	12k	2 off	(M12K)
R19,20	56k	2 off	(M56K)
RV1	2M2 lin pot		(FW09K)
RV2	10k switched log pot		(FW63T)
RV3,4	1M lin pot	2 off	(FW08J)

R23,14 56K

Capacitors

C1,3	4n7 ceramic	2 off	(WX76H)
C2	1uF 63V axial elect		(FB12N)
C4	4u7 63V P.C. elect		(FF03D)
C5	100uF 10V axial elect		(FB48C)
C6,7	10nF mylar	2 off	(WW18U)
C8	10uF 25V axial elect		(FB22Y)

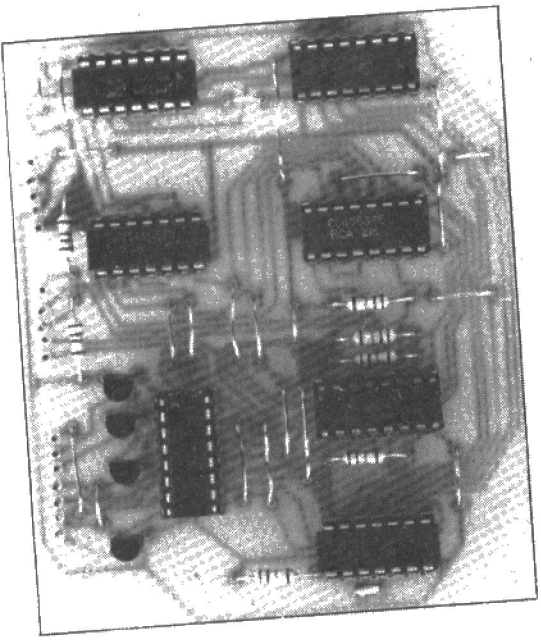
Semiconductors

IC1	CA3240E		(WQ21X)
IC2	LM13700N		(YH64U)
IC3	1458C		(QH46A)
D1,2	1N4148	2 off	(QL80B)

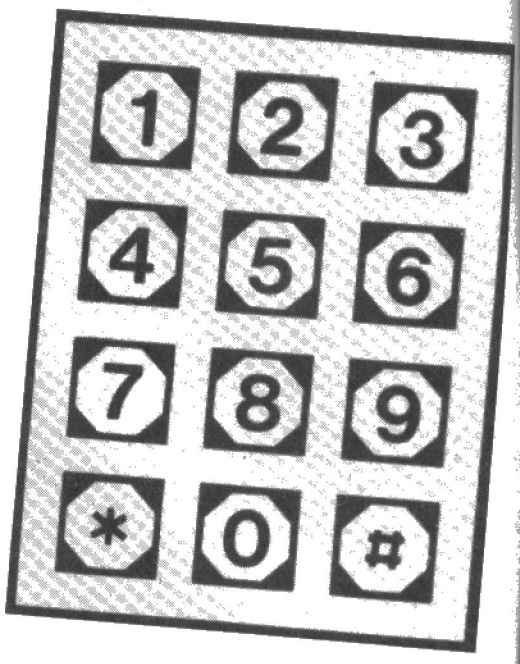
Miscellaneous

JK1,2	Std Open Jacks	2 off	(HF91Y)
S1	Part of RV2		
B1	9 volt PP3 size		
Mic 1	Crystal earpiece		(LB25C)
	Case type MB2		(LH21X)
	Synchime PCB		(GB38R)
	8 pin DIL socket		(BL17T)
	Control knobs	4 off	(YG40T)
	Blue cap		(QY01B)
	Green cap		(QY02C)
	Red cap		(QY04E)
	Yellow cap		(QY06G)
	Battery connector		(HF28F)
	Wire	1 Pkt	(BL00A)
	Synchime Front Panel		(BK77J)

A complete kit of all parts is available.
Order As LK15R (Synchime Kit) **Price £10.90**



CODE LOCK



by Nigel Fawcett

★Fully programmable
★Will work with Maplin Home Security System
★Has a wide range of applications

With the current accent on home security, there have been many designs appearing recently for circuits to protect electrically operated doors or to add to the security of an existing alarm system, by using a code, known only to the owner, that will only disable the associated circuitry when correctly entered on an appropriate keyboard.

Fully programmable units have rarely been included due to their tendency to be costly, consequently extensive use of dummy switches, to fool the unauthorised persons, has been made. This normally means that a soldering iron is the only means of changing the code should it be required (and it frequently is).

The system shown here is fully programmable. A four digit code is used which can be stored and changed at any time simply by switching between read and write mode. (All the external components, plus the PCB but excluding the keypad, should be mounted in a case that is also protected by this device, to prevent access to the read/write switch or any other part of the unit that could render it inoperative).

Circuit Description

The keypad is anotated in exactly the same way as a push-button telephone, with digits 0-9, a hash key and an asterisk key. The hash key is used to arm the system, i.e. take the active high output 'high' and the active low output 'low'. The asterisk key is used to reset the system. This causes the memory address pointer and the number of correct entries counter to be reset to zero. (This also happens on every fourth keystroke). The keys 0-9 are used to enter the code. The four transistors TR1-TR4 are included to allow the use of an SPST type keypad. When a key is pressed, the encoder chip IC2 converts the row/column matrix into a binary code. If either the hash or asterisk symbols are pressed then the system performs a reset or an arm function respectively. If a number key is pressed then operation depends on the state of S1. In write mode, the code is written into the current memory location of the 4*4 bit register chip IC3. The address pointer is stepped onto the next location.

In read mode, the code is sent to the 4063 4-bit comparator IC4, this is then compared with the contents of the current memory location of IC3. If both codes match, then the number of correct entries counter is incremented. In either place the memory pointer is stepped on. If after four consecutive entries bit 2 of the counter is set, then the system will be disarmed, otherwise a reset is performed. Half of IC5 is used as the memory pointer, the other half being the output counter. Half of IC1 is wired as an astable multivibrator to generate the 16kHz clock for IC2, whilst half of IC7 is configured as a flip-flop to provide the active high and active low outputs. The remaining gates are used to decode the arm and reset conditions and to provide the correct polarity for certain data signals.

Construction

Insert all the wire links and resistors. Mount the four transistors and all the IC sockets. The three PCB mounted edge sockets should now be fitted and S1 wired to the appropriate plug. When the PCB has been thoroughly checked for bad joints or short circuits the IC's can be inserted into their sockets.

There are no special setting up procedures.

A five volt power supply is required and the connections for this as well as the wiring to the circuit being protected, are made to SK3. The keypad and S1 should now be connected to SK1 and SK2.

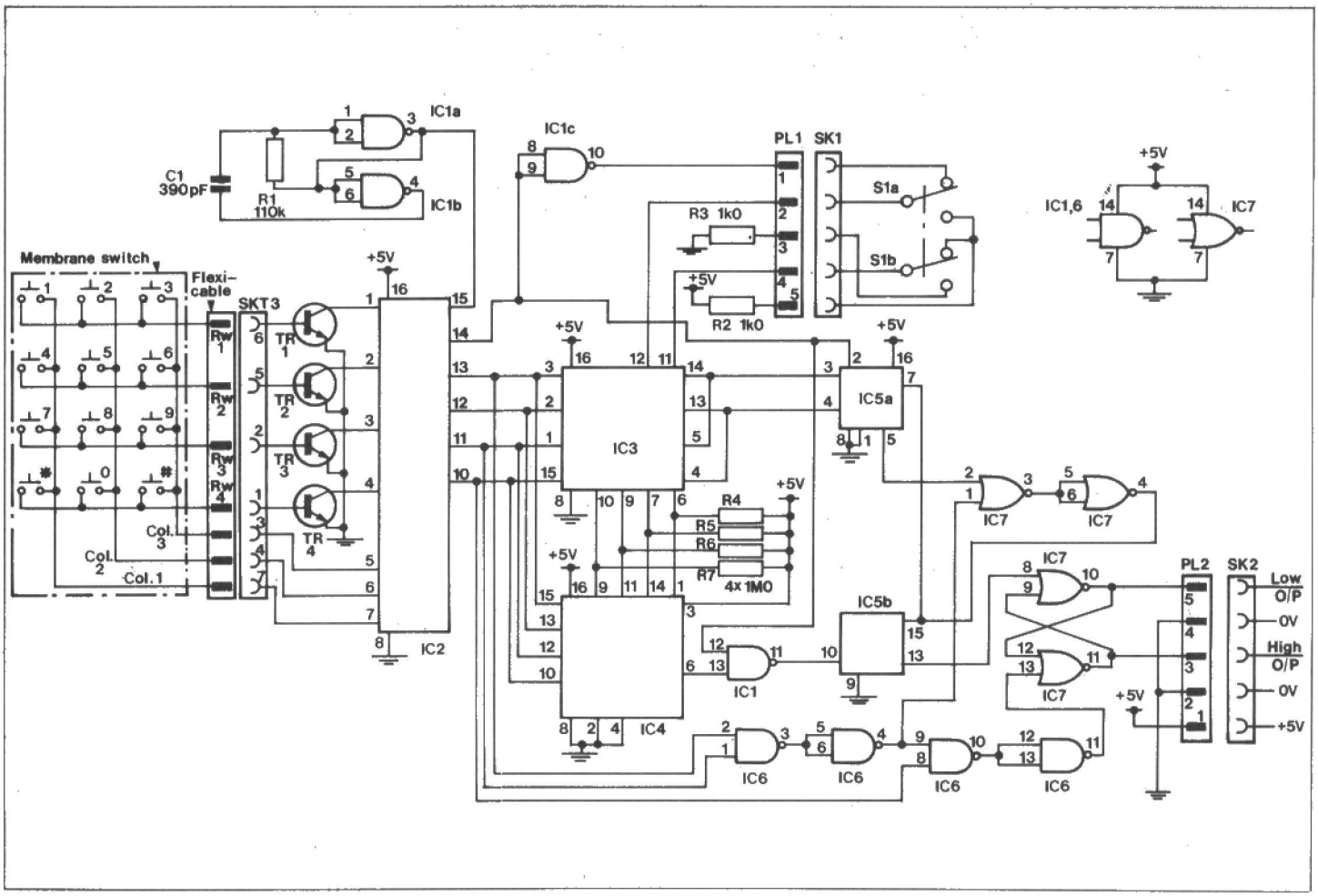


Figure 1. Codelock circuit diagram.

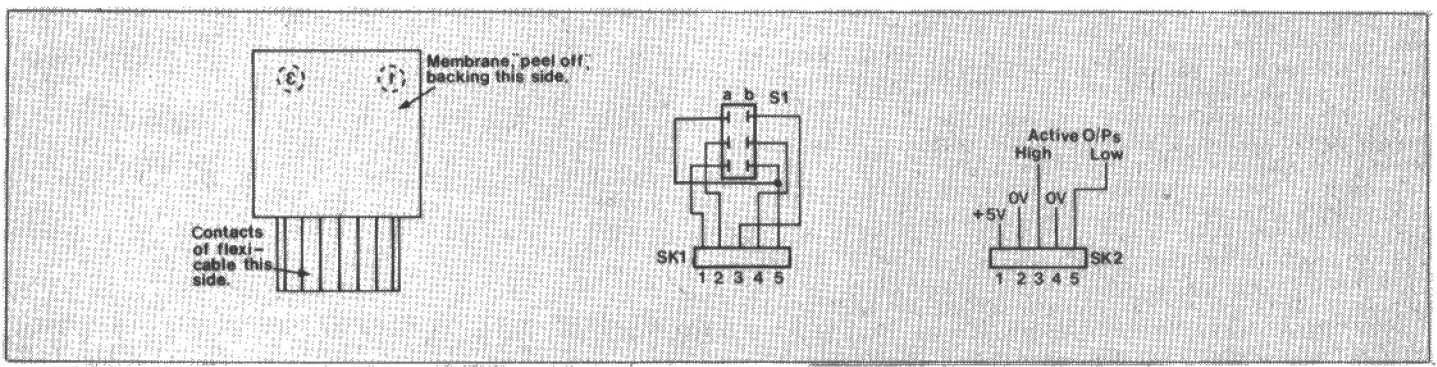


Figure 2. Pinouts.

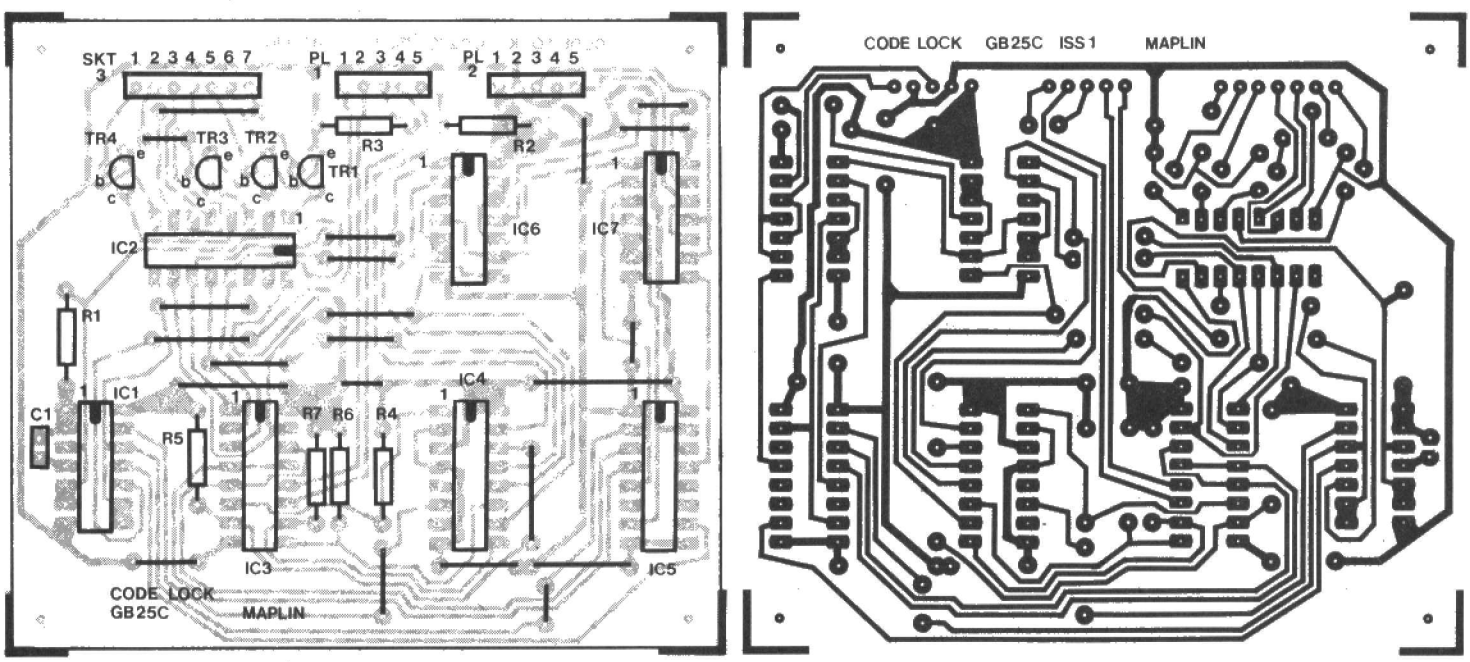
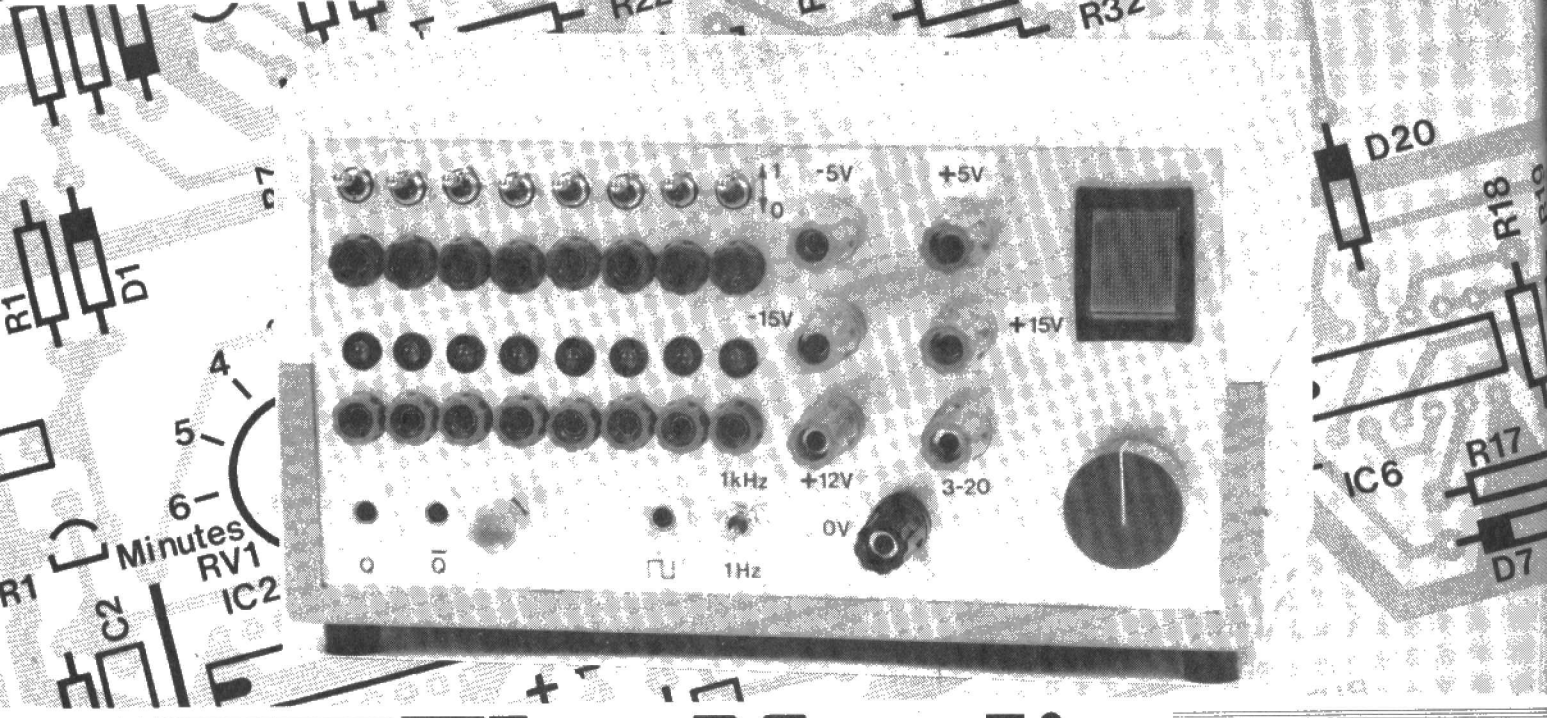


Figure 3. PCB layout.

Continued on page 19



The Maplin MINILAB

by Graham Dixey C.Eng., M.I.E.R.E.

Introduction

The idea for 'Minilab' developed from the need, or desire, to test and experiment with a wide range of digital and linear circuits. This usually necessitates a variety of different supply voltages. For example, when experimenting with op-amps, a dual 15V supply is needed; TTL digital circuits require a +5V supply and some other digital circuits need +12V and -5V e.g. microprocessors and related chips. An infinite variety of linear circuits exist that need unspecified voltages, but usually they are in the range 0 to +20V. The fixed voltages mentioned need to be held within close limits while the same is true of the variable supply once it has been set to a given value; in other words, regulated supplies are essential.

Before the advent of 'chip regulators' such a design to meet all of the foregoing requirements simultaneously would have been rather complex. The general availability of chip regulators that cover a wide range of voltages and current ratings e.g. 7805 (+5V, 1A) or 79L05 (-5V, 100mA) make design and construction simple — there are few external components. The L200 variable voltage regulator is a boon since a very simple variable voltage stabilised supply with current limit facility can now be built at very low cost. In this design the variable voltage supply can deliver a nominal +3 to +20V at 0.45A, though you may well get up to 24V out, and if you want more current, the regulator can give you up to 2A; however, you will have to reduce R4 to about 0.25 ohms and this will also assume that the other outputs are not loaded at the same time, since the

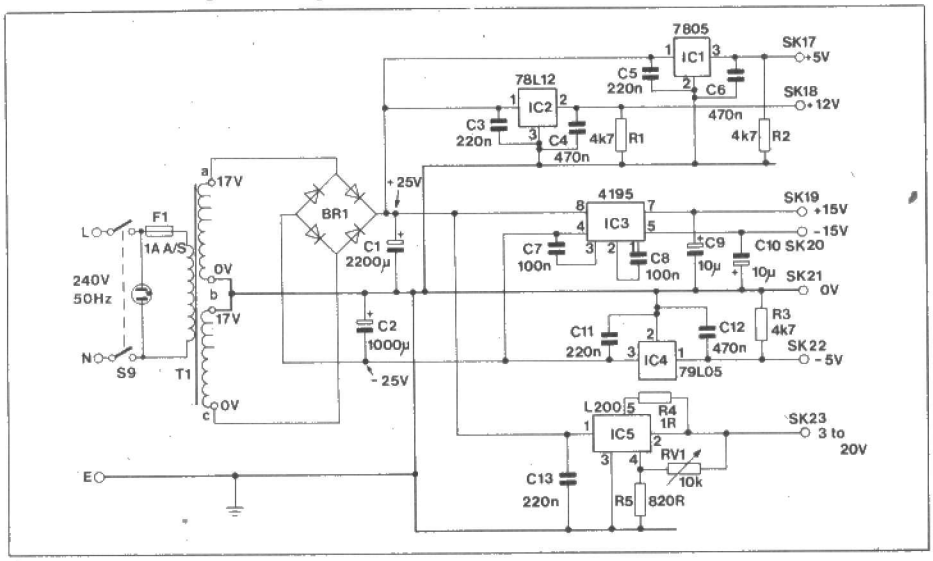


Figure 1. Power supplies.

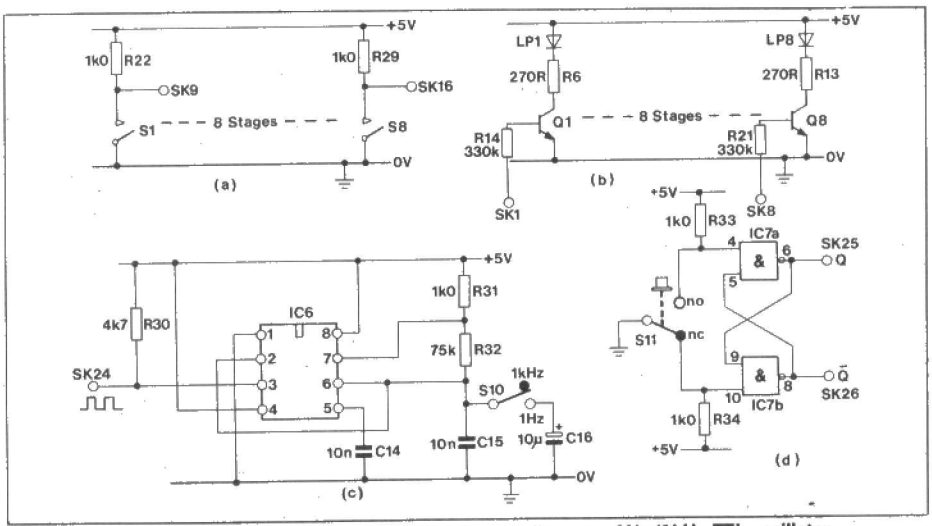


Figure 2. TTL circuits a. TTL level switches b. TTL level indicator c. 1Hz/1kHz TTL oscillator d. de-bounced TTL switch.

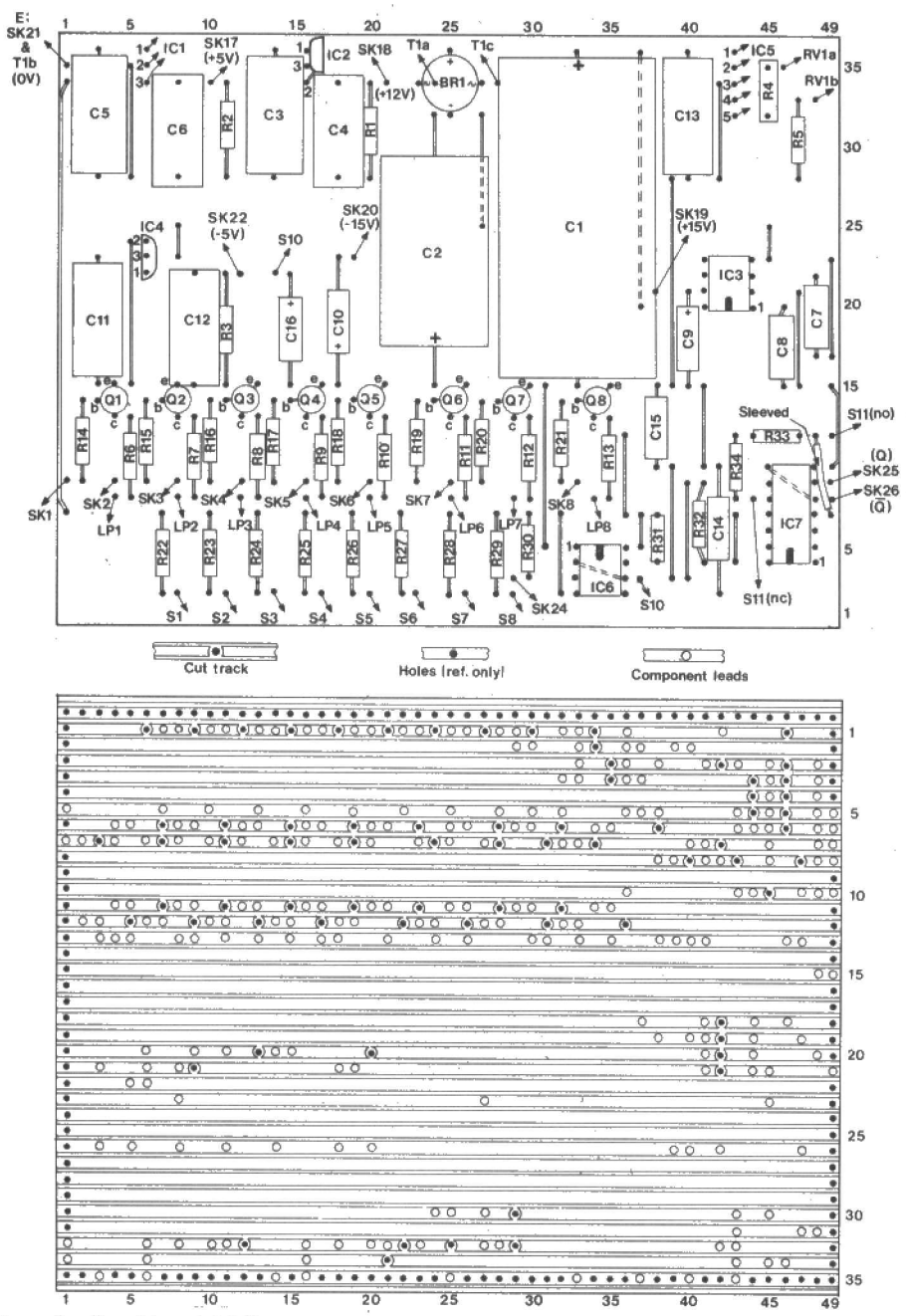
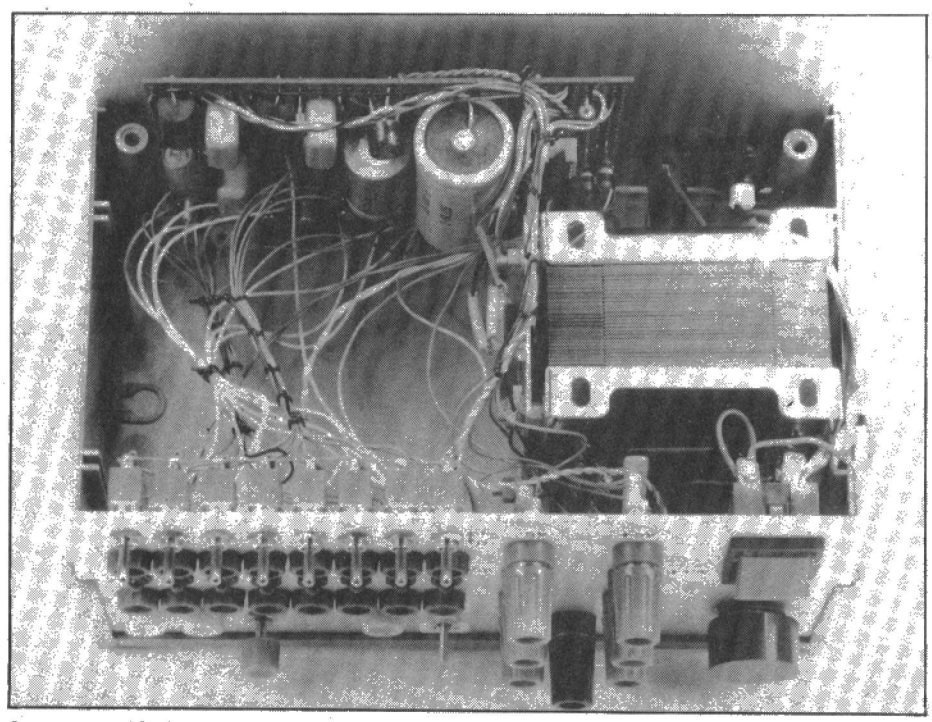


Figure 3. Circuit board details.



limiting factor is the transformer and rectifier, both of which have a rating of 2A.

While a multichannel power supply is useful in its own right, I thought it a good idea to incorporate a few extra, useful but simply provided facilities at the same time.

As a start, there is a set of switches and related sockets that allow the setting-up of eight independent logic levels as inputs to any circuit or system e.g. as variables A, B, C . . . X, Y, Z to a logic gate circuit; or as an 8-bit input to the input/output port of a microcomputer.

Along similar lines is the set of LEDs and associated sockets that will monitor logic levels, whether in a TTL gate circuit, at the outputs of a counter or shift register, or at a microcomputer's input/output port.

In order to study counter or shift register operation a TTL clock input is required. A 1Hz/1kHz square-wave generator provides this facility but there is also a 'debounced' switch so that the operation of such circuits can be observed 'pulse at a time'.

All of the above facilities are shown on the circuits of Figures 1 and 2.

Construction and Testing

As good a starting point as any is the circuit board, which is 0.1" pitch Veroboard, the actual matrix being 49 holes by 36 holes. Use the lower diagram of Figure 3 to identify the 'cut holes' and deal with these first. Then, returning to the face of the board, identify the position of all wire links; fit these (use 22 s.w.g. or 24 s.w.g. T.C.W.), not forgetting those short links beneath the sockets of IC6 and IC7; also noting the sleeved link adjacent to IC7. After this the component order is not too important; a suggested one is: IC sockets, resistors, capacitors, bridge rectifier, transistors and, for the moment, nothing else. Stop now and check that what you have done is correct. What you do next depends upon your level of self-confidence. If you wish to proceed with caution you could, for example, follow the following plan.

First, wire the two transformer secondaries in series (link shown as T1b in Figure 1). Then connect the other two secondary connections (T1a and T1c) to the bridge rectifier (Figure 3) and fit a temporary mains lead and plug. Observing due precautions with regard to personal safety, plug in and check with a DC voltmeter that you have 25V across each of the reservoir capacitors C1 and C2, noting the polarities of these voltages. If these measure correctly then at least the transformer, rectifier and smoothing circuit is alright. Now disconnect from the mains and hook up the connections to IC1 (the heatsink doesn't matter at the moment). Plug in again and check that you have +5V where you should have on the board. Repeat this pro-

cedure for IC2-IC5 in turn until you have all the supplies working; for IC5 you will have to hook up temporary connections to the 10k pot. If all is well you can test the transistor switches Q1 to Q8 by temporarily fitting an LED from each of R6-13 to +5V in turn and each time, using an insulated wire link, touching +5V onto the socket side of each of the base resistors to check whether the LED lights or not.

Concerning the hardware, a standard Verobox is suggested in which there is ample room for the transformer, heatsink and circuit board. The transformer is mounted at the extreme right hand end of the box, long axis vertical and with the mains tappings adjacent to the mains switch. The heatsink (Figure 4) is mounted vertically on the free end of the transformer with four screws, nuts and washers. The heatsink must be spaced off from the transformer frame to prevent the screws which mount IC1 and IC5 from touching the transformer laminations; this is easily done with a small tubular spacer or simply an extra nut behind the heatsink. These two ICs must be mounted on the heatsink by means of a TO220 mounting kit for each (mica washer and plastic bush) to insulate them from each other and from the heatsink itself (N.B. these mounting kits are termed 'TO66 plastic' in the Maplin catalogue and the appropriate part number is given in the parts list). The circuit board can be mounted at the rear of the box using a small angle bracket at each end. The redundant holes in ROW 1 can be opened up where required and there should be no risk of short circuits to any components on ROW 2 if the brackets are fitted right at the ends of the board. If the components face forward the board can sit quite close to the back panel and wiring from the board to the front panel can be carried out without any undue difficulty. Naturally these wires (all identified in Figure 3) are connected to the circuit board before it is mounted in place; estimate a little more for the length of

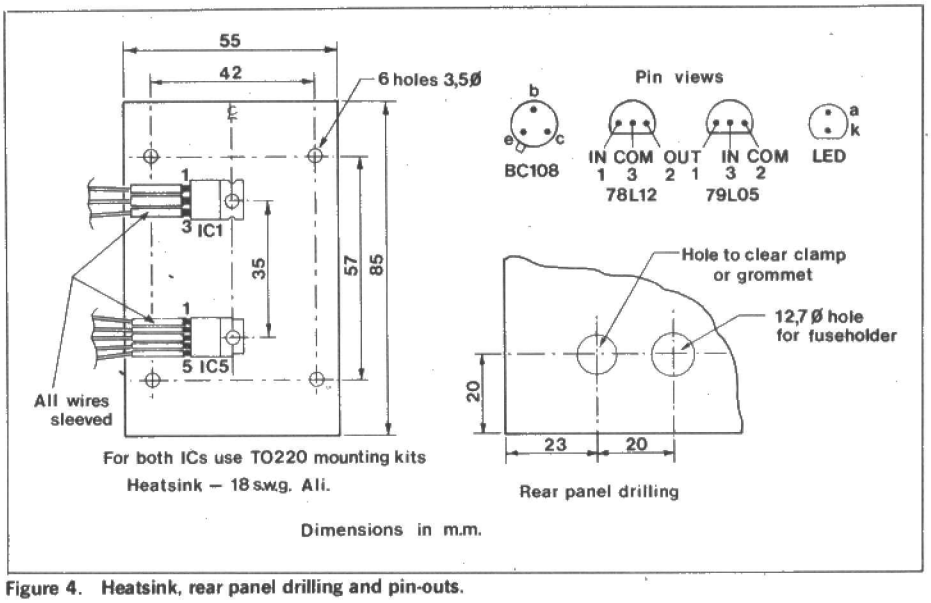


Figure 4. Heatsink, rear panel drilling and pin-outs.

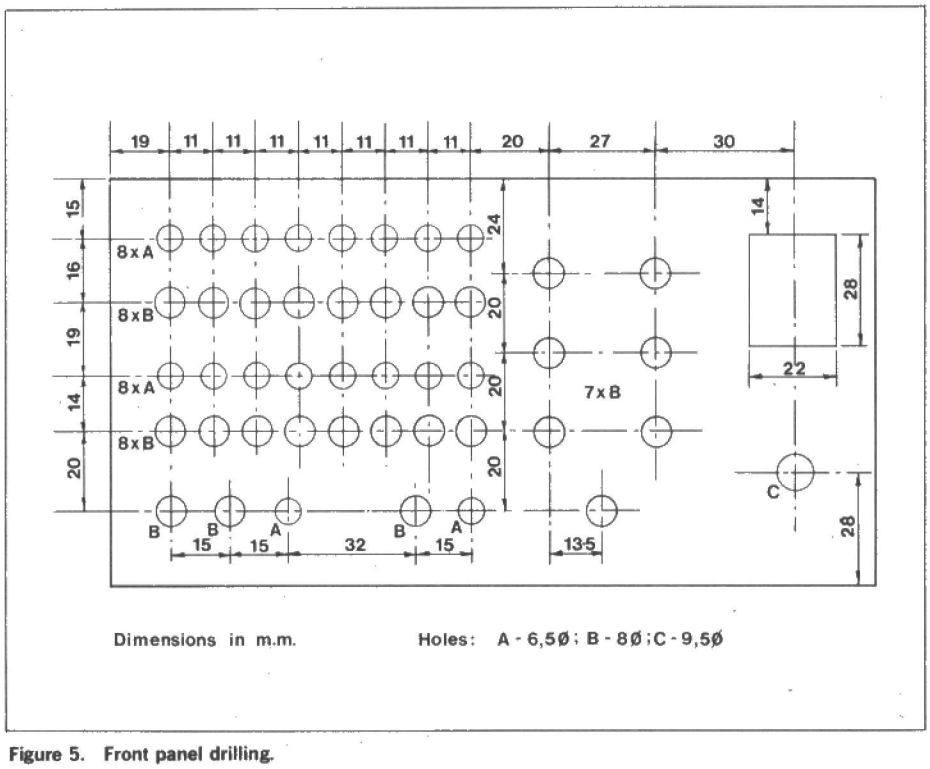


Figure 5. Front panel drilling.

PARTS LIST FOR MINILAB

Resistors – All ¼W 5% carbon unless specified

R1,2,3,30	4k7	4 off	(S4K7)
R4 (3W wirewound)	1R		(W1R)
R5	820R		(S820R)
R6-13	270R	8 off	(S270R)
R14-21	330k	8 off	(S330K)
R22-29,31,33,34	1k0	11 off	(S1K)
R32 (metal film 0.4W)	75k		(M75K)
RV1	10k linear pot.		(FW02C)

Capacitors

C1	2200uF 40V elect.		(FB91Y)
C2	1000uF 25V elect.		(FB83E)
C3,5,11,13	220nF polyester	4 off	(BX78K)
C4,6,12	470nF polyester	3 off	(BX80B)
C7,8	100nF polyester	2 off	(BX76H)
C9,10,16	10uF 25V elect.	3 off	(FB22Y)
C14,15	10nF polyester	2 off	(BX70M)

Semiconductors

Q1-Q8	BC108	8 off	(QB32K)
IC1	7805		(QL31J)
IC2	78L12		(WQ77J)
IC3	4195		(XX02C)
IC4	79L05		(WQ85J)
IC5	L200		(YY74R)
IC6	555		(QH66W)
IC7	7400		(QX37S)
BR1	W01		(QL38R)
LP1-8	LED	8 off	(WL27E)
—	Clip for above	8 off	(YY40T)

Miscellaneous

T1	Transformer 0-17V, 0-17V @ 2A		(WB22Y)
—	Case (Verobox)		(LL07H)
S1-8,10	Sub. min. toggle switch	9 off	(FH00A)
S9	Mains switch DPST (with neon)		(YR70M)
S11	Min. push-button switch SPDT 10mm cap green		(BK68Y) (BK71N)
SK1-8	4mm socket – green	8 off	(HF72P)
SK9-16	4 mm socket – brown	8 off	(HF71N)
SK17,18,19,23	4mm terminal – red	4 off	(HF07H)
SK20,22	4mm terminal – blue	2 off	(HF03D)
SK21	4mm terminal – black		(HF02C)
SK24	4mm socket – yellow		(HF75S)
SK25,26	4mm socket – white	2 off	(HF74R)
	DIL socket 8-pin	2 off	(BL17T)
	DIL socket 14-pin		(BL18U)
	Mounting kit TO220	2 off	(WR23A)
F1	Fuseholder 20mm		(RX96E)
	1A antisurge fuse		(WR19V)
	Veroboard 10347		(FL09K)

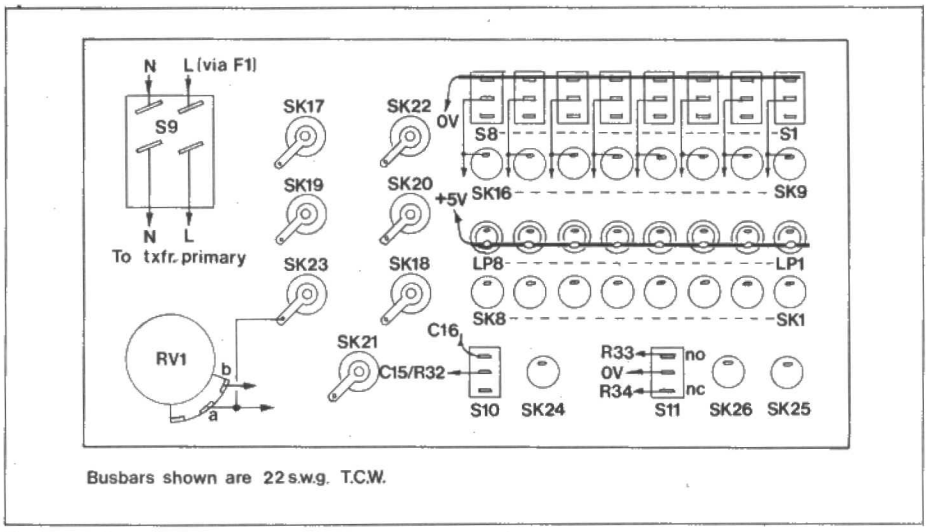
A complete kit of all parts, excluding the case, is available for this project.
Order As LK09K (Minilab kit). Price £32.50.

each wire than is actually needed. As a tip to make life that bit easier, the two wires to the pot. are best wired to the pot. first and then to the circuit board, since the pot. tends to be obscured by the transformer once the front panel has been dropped into place.

There is little comment to make on the front panel wiring except to point out the bus-bars used to common the anodes of the LEDs (and taken to the +5V terminal SK17) and a similar bus-bar on switches S1-S8, which is taken to the 0V terminal SK21. Figure 6 shows all of these details and identifies the position of all front panel components. The front panel drilling details appear on Figure 5.

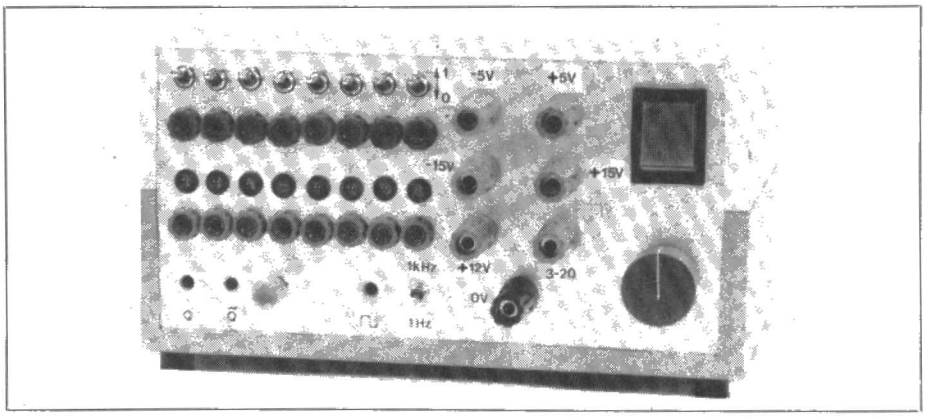
The rear panel has only two holes (details in Figure 4), which are for the mains cable clamp or grommet and the fuseholder. This is best drilled and put aside until all else is finished. This simply means wiring from the circuit board to the front panel, dropping the rear panel into place, completing the mains wiring via fuse F1 and testing the complete 'Minilab' to see that the following facilities exist:

+5V @ 1A	Eight TTL outputs
±5V @ 100mA	Eight TTL inputs
+12V @ 100mA	1Hz/1kHz TTL oscillator
+15V @ 50mA	One bounce-free, TTL pair of complementary outputs (Q and $\bar{Q}$)
+3V to +20V @ 450mA	



Busbars shown are 22 s.w.g. T.C.W.

Figure 6. Front panel rear view — component identification.



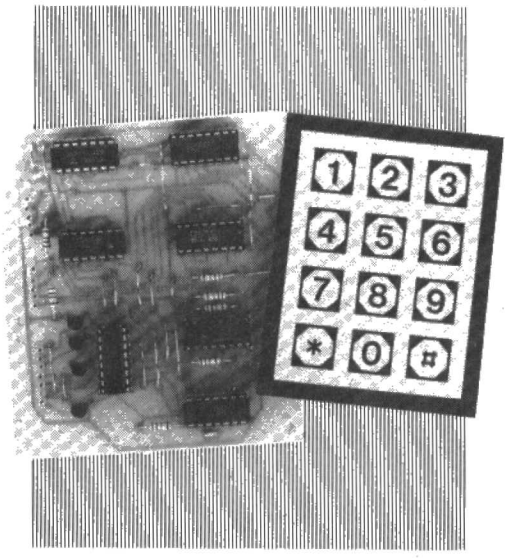
CODELOCK *Continued from page 13*

Application

The applications for a circuit such as this are many and varied, making it difficult to list all of the possibilities, however here are some suggestions.

First and foremost, any form of burglar alarm is an obvious candidate. Here the usual key that would be used to Arm or Disarm the system could be replaced by a Codelock, or as an even more security conscious suggestion, it could be inserted in parallel with the keyswitch, which would mean that both the key and the secret code would be required before the alarm could be deactivated.

The second most obvious application would be to use the Codelock in conjunction with a commercially available electric door lock. This would give tremendous security to, say a computer room, photographic darkroom, office or any number of places where unwelcome visitors would rather be kept out.



Lastly, any device that is normally operated by means of an ordinary switch, could have a Codelock to replace the said switch, barring the devices use from those other than yourself or those to whom you have disclosed the code. In this, and indeed most applications, the output from the Codelock would have to drive a relay or some form of servo or triac to act as the mechanical part of the switch. It is because of the number of different ways in which the Codelock could be utilised, that no final drive circuitry has been included, as this would depend on how it is to be used.

PARTS LIST CODE LOCK

Resistors: All resistors 0.4W 1% metal film unless specified.

R1	110k		(M110K)
R2,3	1k0	2 off	(M1K0)
R4-7	1M0	4 off	(M1M0)

Capacitors

C1	390pF ceramic		(WX63T)

Semiconductors

TR 1-4	BC 548	4 off	(QB73Q)
IC1,6	4011BE	2 off	(QX05F)
IC2	MC14419		(QY55K)
IC3	74LS170		(YF72P)
IC4	4063BE		(QW41U)
IC5	4518BE		(QX32K)
IC7	4001BE		(QX01B)

Miscellaneous

SW1	Switch sub. min. slide		(FH35Q)
	Membrane Switch		(BK72P)
SK3	Flat Flex Connector		(BK73Q)
PL1,2	Minicon plug 5 way	2 off	(FY93B)
SK1,2	Minicon latch housing 5 way	2 off	(BH66W)
	Minicon terminal	10 off	(YW25C)
	PC Board		(GB25C)

A complete kit of all parts is available.
Order As LK14Q (Code Lock kit) Price £19.98.

INTERFACING THE BBC MICRO

by Robert Penfold

The BBC model B microcomputer seems to be popular with those who are interested in using a computer for control or measurement applications, and it is well suited to this type of use. It seems to have more input and output sockets than any other microcomputer currently available, including a four channel 12 bit analogue to digital converter, serial and parallel printer interfaces, an 8 bit (plus handshaking lines) user port, and the 1MHz Bus which enables additional input and output ports to be easily added. It also has a fast version of BASIC plus a built-in assembler which makes it relatively easy to use machine code when very high speed operation is essential.

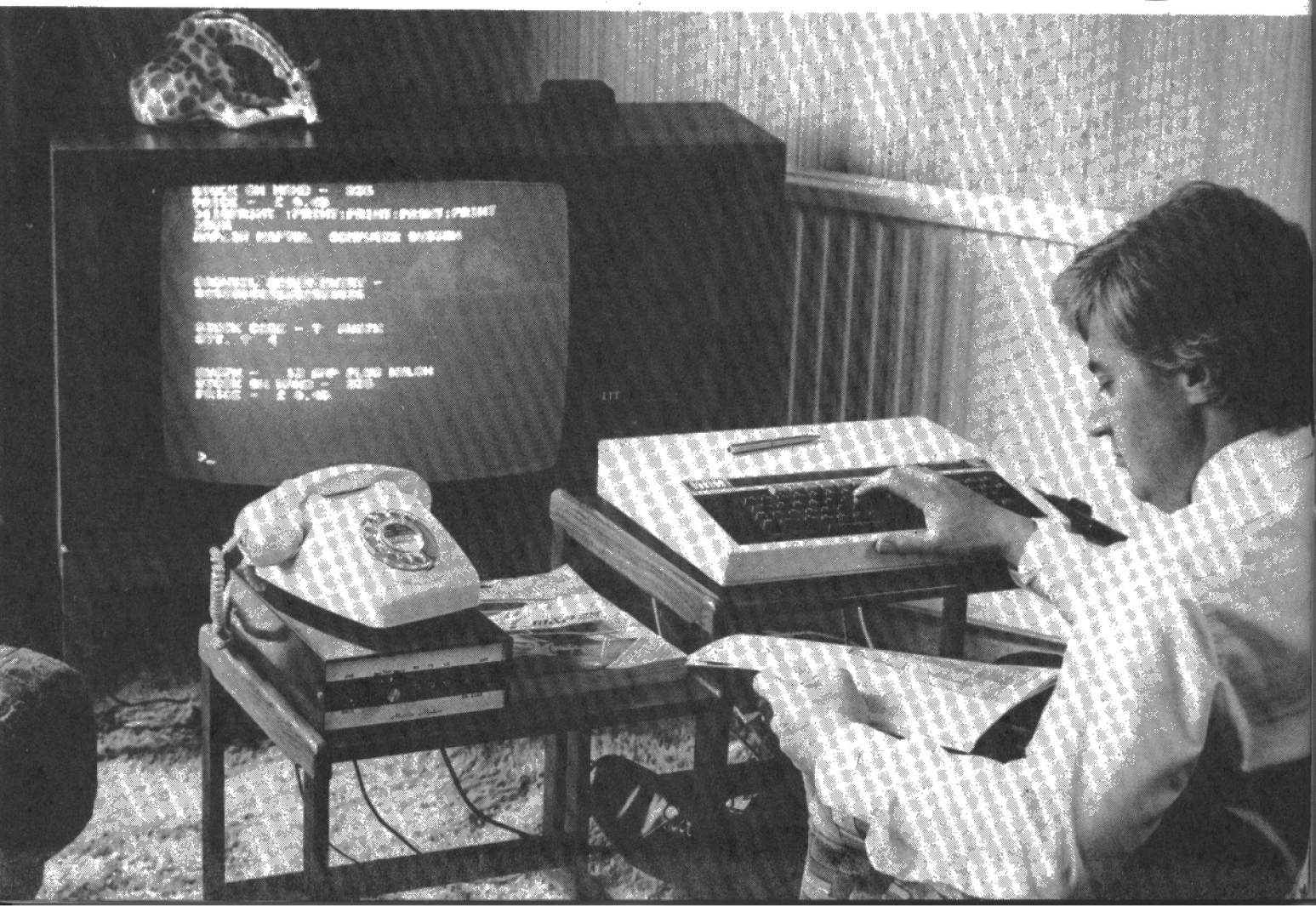
A certain amount of information about interfacing the BBC micro is given in the "User Guide" provided with the machine, but some of this can be a little difficult to understand unless you are already familiar with the techniques and interface devices used. In this article topics such as programming the user port, using the handshaking lines, and adding extra ports to the 1MHz Bus will be covered, filling in some of the detail which is absent from the "User Guide."

User Port

Both the parallel printer and user ports are provided by a 6522 VIA (Versatile Interface Adaptor) device, and this is also used to provide the machine with its Basic "TIME" function. The two timer/counters of the 6522 are available to the user, but these can only be used in machine code programs and would not normally be used directly. In most applications the Basic "Time" command is adequate, and the direct use of the timer/counters will not therefore be considered here.

The two 8 bit ports of the 6522 (called the "A" and "B" ports) are very similar, and each bit of both ports is individually programmable as an input or an output. However, an important point to bear in mind is that the "A" port is used to drive the parallel print output via a 74LS244 buffer. This is a tri-state buffer, but it is permanently enabled so that it operates as a straightforward TTL buffer. The printer port can therefore be used in much the same way as the user port, but only if output lines are required. The data lines of the parallel printer port cannot be used as inputs.

Writing to the appropriate register of the 6522 determines whether each data line of the "B" port is designated as an input or an output. This is called the "data direction register" and is at hex address FE62. Writing a 1 in a bit of this register causes the corresponding data line to operate as an output, and a 0 causes the corresponding data line to act as an input. For example, sending 15 (00001111 in binary) to the data direction register sets the four higher data



lines (PB4 to PB7) as inputs, and the four lower lines (PB0 to PB3) as outputs.

With BBC BASIC the usual PEEK and commands are replaced by a question mark (?) which denotes that the number which follows is an address. Thus, in order to write 15 to hex address FE62 the program line would read:-

?&FE62 = 15

The "&" before the address is needed to inform the computer that the address number is in hex and not in decimal.

It is important to note that address &FE62 is the location of the data direction register and this is not the address used when reading from or writing to the user port. The relevant address for this is &FE60. As a safety measure the data direction register is set to zero at switch on so that there can be no problems if a peripheral device is feeding an input signal to the user port. If you type:-

PRINT ?&FE&0 RETURN

into the computer, 255 should be printed on the screen, since pull-up resistors take the user port inputs to logic 1 if they are simply left floating. Wiring some of the lines to OV pins of the port should give a suitably modified result if the command is retyped.

If you remove the shorting wires and try typing:-

?&FE62 = 255 RETURN

?&FE60 = 15 RETURN

the data lines of the user port are all set as outputs by the first line, and the second sets PB0 to PB3 high and PB4 to PB7 low. The outputs latch, and the appropriate output states can be confirmed using a logic probe or multimeter.

In some applications it is necessary to read just one bit of the user port, or to read several bits one at a time. Strictly speaking this is not possible, but using the logic AND function it is possible to mask all but one bit. For example, suppose we wish to know if PB4 is low or high. If it is at logic 1 this line adds 16 to the number returned from the user port, and it is therefore ANDed with the number 16. For the sake of this example we will assume that the number returned from the user port is 255. The two numbers are logic ANDed bit by bit, as shown below, giving a logic 1 in the binary result only if that particular column has a 1 in both the figures being ANDed (i.e. in both the first number AND the second).

255	11111111	user port
16	00010000	number used to mask all but PB4
16	00010000	answer

If PB4 was low and the number returned from the user port was (say) 239 this would give the following result:-

239	11101111	user port
16	00010000	number used to mask all but PB4
0	00000000	answer

If you try typing into the computer:-

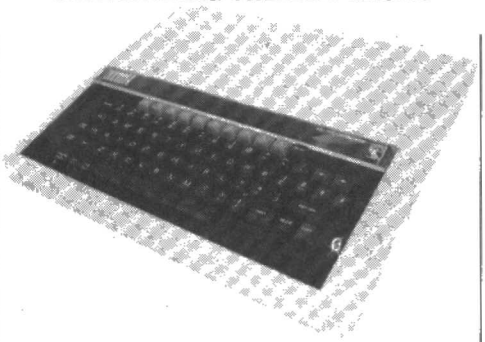
PRINT ?&FE60 AND 16 RETURN

the number returned should be 16. Taking PB4 and any of the other input lines to OV should return to 0 if the command is repeated.

By using the appropriate mask number it is possible to effectively read any one bit or selected bits of the user port.

Handshake Lines

When a computer is sending data to or receiving data from a peripheral device it is often necessary to have some form of synchronisation so that data transfers are only attempted when both pieces of equipable to deal with them. It is for this purpose that handshaking lines CB1 and CB2 are



provided on the user port. CB2 can be used as an input or an output, but CB1 can only be used as an input.

Some of the ways in which these lines are used are quite complex and go beyond the scope of this article, but there are some relatively simple but useful ways in which they can be used. CB1 and CB2 are made to operate in the required manner by writing the appropriate number to the Peripheral Control Register which is at address &FE6C. An input from one of these lines gives a change in one bit of the Interrupt Flag Register which is located at address &FE6D. When CB1 is activated it sets bit 4 of the Interrupt Flag Register high, and when used as an input CB2 sets bit 3 of this register high. In other words the number returned from ?&FE6D is raised by 16 and 8 (in decimal) respectively.

CB1 is the more simple of the two handshaking lines since it only has two modes of operation, and it is controlled by one bit of the Peripheral Control Register (bit 4). CB2 has four input modes and four output modes and is controlled by three bits of this register (bits 5 to 7). The table given below summarizes the modes of CB1 and CB2.

Binary/ Decimal No.	Mode of Operation
0/0	CB1 high to low handshake input
1/16	CB1 low to high handshake input
000/0	CB2 high to low handshake input
001/32	CB2 high to low independent input
010/64	CB2 low to high handshake input
011/96	CB2 low to high independent input
100/128	CB2 high to low handshake output
101/160	CB2 high to low pulse output
110/192	CB2 constant low output
111/224	CB2 constant high output

When dealing with CB1 it is simply a matter of selecting a high to low or low to high transition to set the interrupt flag. With CB2 there are the same two options, plus the two independent modes. When using the handshake modes the relevant bits of the Interrupt Flag Register can be reset by reading from or writing to the user port, or by writing a 1 to the appropriate bit or bits of the Interrupt Flag Register (i.e. use ?&FE6D = 16 to reset the CB1 flag, ?&FE6D = 8 to reset the CB2 flag, or ?&RE6D = 24 to reset either of them). With the independent modes this second method is the only way of resetting the flags.

The simple program given below can be used to try out the CB1 and CB2 inputs.

```
10 ?&FE6C = 0
20 CLS
30 PRINT ?&FE6D
40 ?&FE6D = 24
50 TIME = 0
60 REPEAT UNTIL TIME = 100
70 GOTO 20
```

This simply prints the value of ?&FE6D and updates the reading at roughly one second intervals (the delay time set by lines 50 and 60). Line 10 sets all the control registers at zero so that both CB1 and CB2 set their respective interrupt flag registers during a transition from the high state to the low one, and they are both used in the handshake mode. By taking CB1 and (or) CB2 low the initial reading of 0 should change to 8, 16, or 24, as appropriate. However, line 40 resets the interrupt flags and the reading should soon return to zero. As the handshake mode is used, reading from the user port (by putting X = ?&FE60 at line 40, for example) should also reset the flags. By changing the number at line 10 the other input modes can be tried using this program.

The CB2 output modes are quite straight forward. In the two constant modes CB2 is set high or low as required, and is independent of the other user port lines. In the pulse mode it provides a 1us negative pulse each time data is sent to the user port, and in the handshake mode it goes low when data is sent to the user port. It can then only be reset to the high state by an active transition on CB1.

The lower four bits of the Peripheral Control Register function in the same way as bits 4 to 7, but they control lines CA1 and CA2 of the printer port. The printer port is at ?&FE61 and its Data Direction Register is at ?&FE63. The interrupt flags for CA1 and CA2 are bits 1 and 0 respectively of ?&FE6D.

1MHz Bus

An 8 bit user port is obviously very useful, but you may well find that more inputs or outputs are required. The most simple solution to the problem is to use the parallel printer port, but this only provides another 8 lines plus handshaking lines and the 8 data lines (as explained earlier) can only be used as outputs. The 1MHz Bus offers great scope for expansion, and some simple hardware is all that is needed to provide one or two extra input or output ports.

The circuit diagram on page 503 of the "User Guide" shows the various inputs/outputs available on the 1MHz Bus, and this includes the data bus (DO to D7) and the lower 8 address bus lines (DO to D7). Only the lower 8 address lines are needed as the upper 8 lines are decoded and provided in the form of lines NPGFC and NPGFD. The former pulses negative when any address in page FC is addressed, and the latter similarly pulses low for any page FD address. This gives a generous quota of 512 addresses for user hardware from ?&FC00 to ?&FDFF, although Acorn only recommend ?&FCCO to ?&FCFE for user applications. The other addresses are allocated to such things as an extra 64k of memory, a Teletext Unit, and a Prestel Unit. However, if you do not intend to add equipment of this type to the 1MHz Bus, and just require a simple input or output port, it is very easy to make these additions.

Figure 1 shows how an 8 bit input port can be added. This circuit is based on a 74LS244 octal tri-state buffer, and this must be enabled (by taking pins 1 and 19 low) each time there is a read operation to the port. The most simple way of achieving this is to simply connect these pins to NPGFC or NPGFD, but a drawback of this system is that an accidental write operation to the port would result in the MPU and the port simultaneously placing an output on to the data bus. This possibility can be eliminated by gating the read/write line and NPGFC or NPGFD so that IC1 can only be enabled during read operations (when the read/write line is high). In this circuit the necessary gating is provided by three of the 2 input NOR gates of IC2.

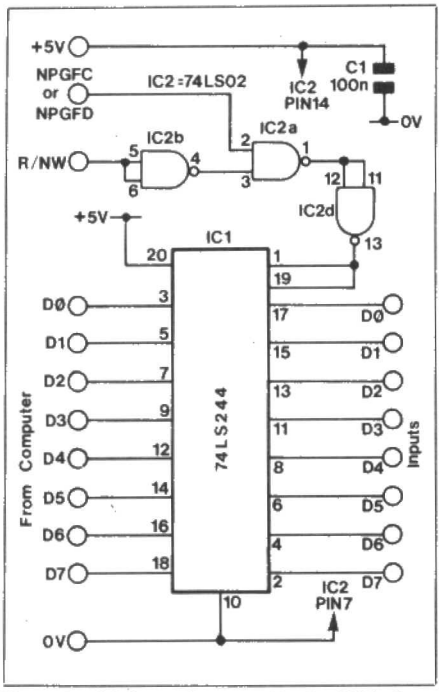


Figure 1. Adding an input port to the 1MHz Bus.

A simple output port can be added using the circuit of Figure 2. This is just a 74LS273 octal D type flip/flop which is fed from the data lines and is latched by the negative pulse from the NPGFC or NPGFD line each time a write operation is performed. As the port cannot place an output onto the data bus there is no need to gate the read/write line with the NPGFC or NPGFD line.

With both of these circuits the port will respond to any address from &FC00 to &FCFF if the NPGFC line is used, or from &FD00 to &FDFF if the NPGFD line is used. This permits only one piece of hardware per line to be used, and it is therefore better to use a more sophisticated system if further expansion is contemplated. Another limitation of these simple circuits is that they do not provide handshake lines, and there is just a negative pulse from the NPGFC or NPGFD line each time a port is written to or read from.

6821 PIA

A more elegant solution to additional input/output ports is to use a 6821 PIA (Peripheral Interface Adaptor) plus full decoding of A0 to A7 address lines, as shown

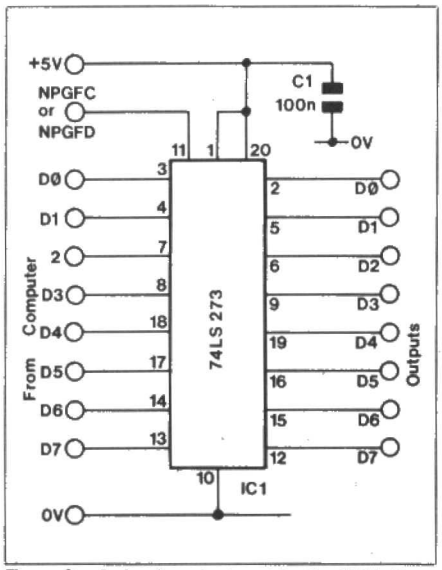


Figure 2. A simple output port for the 1MHz Bus.

in the circuit of Figure 3. This gives two 8 bit ports with each line individually programmable as an input or output. There are also two handshake lines per port.

IC1 is a 74154 (or 74LS154) 4 to 16 line decoder, and this has 16 outputs, one of which will be in the low state if the device is enabled. Which output this is depends on the binary number fed to the four address inputs of the device (A0 to A3). These inputs are fed with the A4 to A7 lines of the 1MHz Bus, and output 12 (C in hex) of IC1 is the only one which is used in this case.

IC1 has two enable inputs which must be taken low in order to permit normal operation of the device, and these are fed from the A2 and A3 lines of the 1MHz Bus. The remaining two address lines (A0 and A1) are fed to the Register Select inputs of IC2 and determine the operating mode of this device.

D1, D2, and R1 form a simple gate which gives a negative signal to the negative chip select input of IC2 when the NPGFC line is activated, and the A2 to A7 lines of the 1MHz Bus are at the correct states to operate IC1. This places IC2 at the four addresses from &FCC0 to &FCC3, which is within the range of addresses that Acorn recommend for user applications. This leaves all the other 508 addresses in pages &FD and &FC available for use.

The reset input of IC2 is fed from the NRST line so that the device is reset at switch-on or when the BREAK key is operated. The read/write input of IC2 is fed from the corresponding line of the 1MHz Bus so that IC2 is automatically set to the appropriate mode. The enable (E) input of the 6821 has a slightly misleading name, and this must be fed with the clock signal so that the computer and the PIA are correctly synchronised. Although the BBC micro has a 2MHz clock, this is divided by 2 to give a 1MHz clock frequency for peripheral devices, including the internal 6522 VIA, incidentally. Thus a standard 6821 can be used for IC2, and it is not necessary to employ the faster 68B21. The two interrupt request outputs of IC2 have open drain driver transistors so that they can be wired together to give an OR function. They can be connected to the interrupt request line of the 1MHz Bus, but it is only worthwhile doing this if you fully understand the use of interrupts, and actually intend to use them. Otherwise it is better to leave these outputs unconnected, so that the possibility of producing an unintentional interrupt and "crashing" the computer is eliminated.

Using the Ports

There are six registers in the 6821; the data direction register (DDR) for port A, the port A peripheral register, the port A control register, and the equivalent three registers for port B. With the circuit only occupying four addresses it is obviously not possible to gain direct access to all six of these. It is only possible to directly access the port A and port B control registers at ?&FCC1 and ?&FCC3 respectively. These registers control access to the other four registers, control the handshake lines of their respective ports, and receive inputs from these lines.

In order to gain access to a DDR, bit 2 of the corresponding control register must be set to zero. As all the registers are reset to zero at switch-on this initially gives direct access to the port A and port B DDRs at ?&FCC0 and ?&FCC2 respectively. Use of the DDRs is much the same as for the 6522, with bits being set at 0 or 1 to set the corresponding port data lines and inputs or outputs. The reset at switch on sets all the

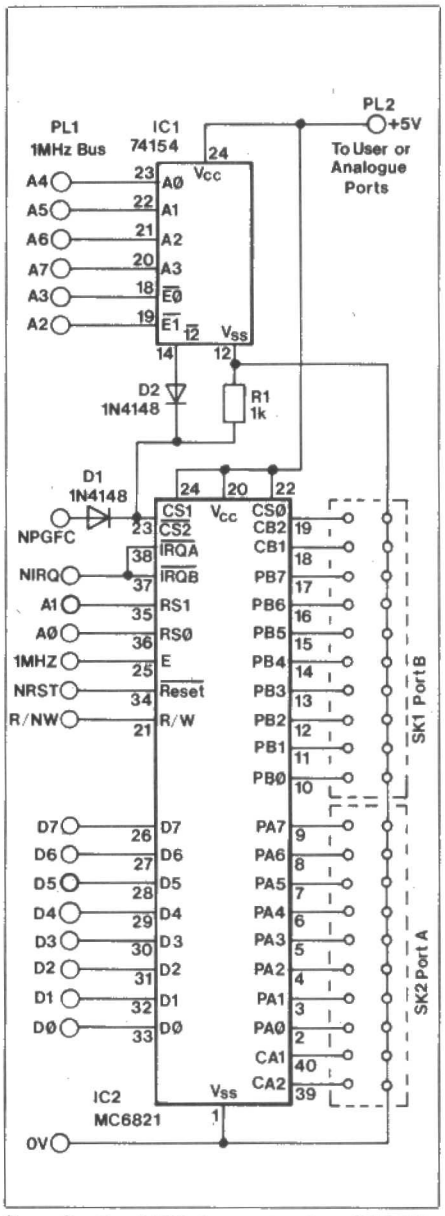


Figure 3. Two 8-bit in/out ports using a 6821 PIA.

data lines as inputs initially.

Read and write operations to the ports are performed via the peripheral registers, and bit 2 of the correct control register is set at 1 (e.g. ?&FCC1 or ?&FCC3 = 4) to give access to the A and B peripheral registers at ?&FCC0 and ?&FCC2 respectively. In other words there is both a peripheral register and a DDR at each of these addresses, and whichever of these is required is selected by setting bit 2 of the appropriate control register at 1 or 0. For example, to send the value 65 to port A the following program could be used:-

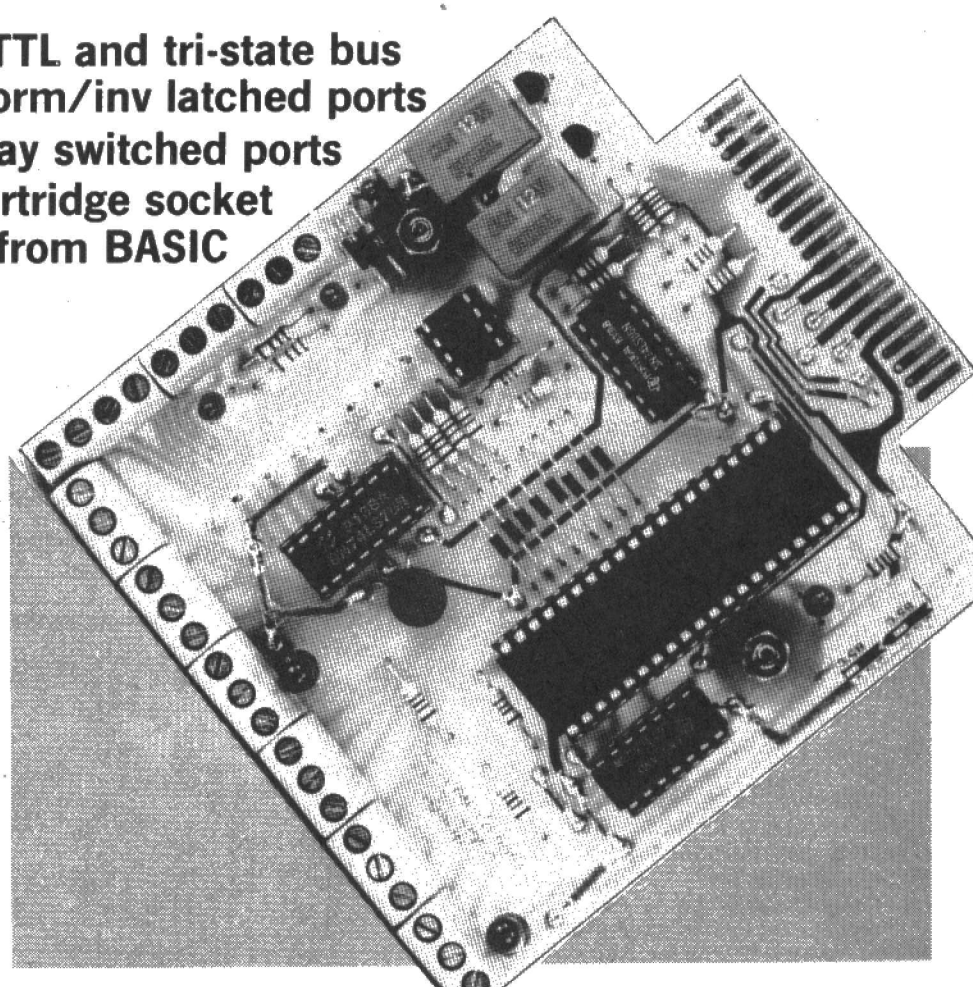
```
10 ?&FCC1 = 0    (if required, gives access to DDRA)
20 ?&FCC0 = 255(Sets port A lines as outputs)
30 ?&FCC1 = 4    (gives access to peripheral register A)
40 ?&FCC0 = 65   (writes 65 to port A)
```

The table shown in Figure 4 should be helpful when writing programs which use the two 6821 ports. Port A and port B are slightly different, and port A, for instance, has pull-up resistors when it acts as an input, whereas port B does not. In practice there is unlikely to be any problem in using either port with TTL ICs to drive transistor switches, etc., but if in doubt the 6821 data sheet gives a substantial amount of information about the output drive capability and input requirements.

Continued on page 26

Dragon 32 Input/Output Ports

★ Two 8 bit ports with TTL and tri-state bus compatibility ★ Four norm/inv latched ports ★ Two opto and two relay switched ports ★ Module plugs into cartridge socket ★ Fully programmable from BASIC using PEEK and POKE



by Dave Goodman

Our port interface module allows the Dragon 32 to communicate with external devices such as micros, domestic electrical systems, i.e. central heating and security control, or peripheral control of the computer.

Input/Output ports consist of eight terminals, each of which can access the computer data bus. Information is passed along the bus, to or from the Central Processing Unit (CPU), by enabling the port with appropriate control signals. POKEing data in decimal form (Ø to 255) will result in an eight bit binary code being written to the port, whilst PEEKing will read presented information and take action according to program requirements.

Circuit Description

The four address codes 49152 to 49155 are used to control IC2, using R2 enable signals. Port B, PBØ to PB7 are TTL compatible with normally low outputs, while port A, PAØ to PA7 are tri-state bus compatible outputs. Port C is selected, along with port B, by enabling IC3 with IC1c. Input or output signals present at port B will operate RLA, RLB via IC3 A,B; the dual opto isolator IC5 via IC3c,d, and enable the four bit latch IC4.

PC4 to PC7 Q outputs are normally high, and $\overline{Q}$ are normally low (OV). D1 to D8 buffer port C from port B, making it write only and accessible either from the CPU or externally with +5V to 0V signal levels.

Construction

Insert 32 track pins from side two, through the holes marked with a circle. Solder these to both sides of the PCB. Bend all the leads of the 18 resistors, and insert them into the board. Refer to the parts list for values, and if using 5 band 1% resistors note that colour coding begins at the end opposite to that of the solitary brown band. Fit D1 to D8. These diodes are usually blue in colour, with a black band at one end. This band must be aligned with the white band legend on the PCB. Fit diodes D9 and D10. Although they are larger in size and black in colour the band rule still applies. Capacitors C1 to C4 may now be inserted. C1 and 2 are tantalum types with a + sign printed on the body. Fit the lead closest to this through the hole marked + on the PCB. C4 has a - sign, not a + sign. Take this into consideration before you fit it. All 5 IC sockets can now be fitted, along with TR1 and TR2.

It is advisable, at this stage, to solder all fitted components and remove excess leads before continuing further. Insert both relays. They will only fit one way round, and bend the flexible leads over each pad to secure. LEDs 1 and 2 are the larger LEDs, and 3 and 4 the smaller ones. These can all now be fitted. Each cathode (k) is recognised either by the shorter of the leads, or by a flat section on the body skirting.

Place 6 of the three way terminals in positions PAØ to PA7 and PBØ to PB7. The remaining 2 three way terminals to relay port PCØ and PC1. The four way terminal is fitted to PC2,3 position. Check each terminal faces the outside edge of the PCB before soldering, then insert the 8 vero pins in positions PC4 to PC7. Solder, trim, and inspect your work, then fit all 5 ICs.

Two rubber feet, bolts and nuts can be fitted to side 1 of the PCB, through the 4BA holes drilled for this purpose. They have been included to prevent wobble and excess strain on the edge connector, which could result in lost data or worse. Provided that all instruc-

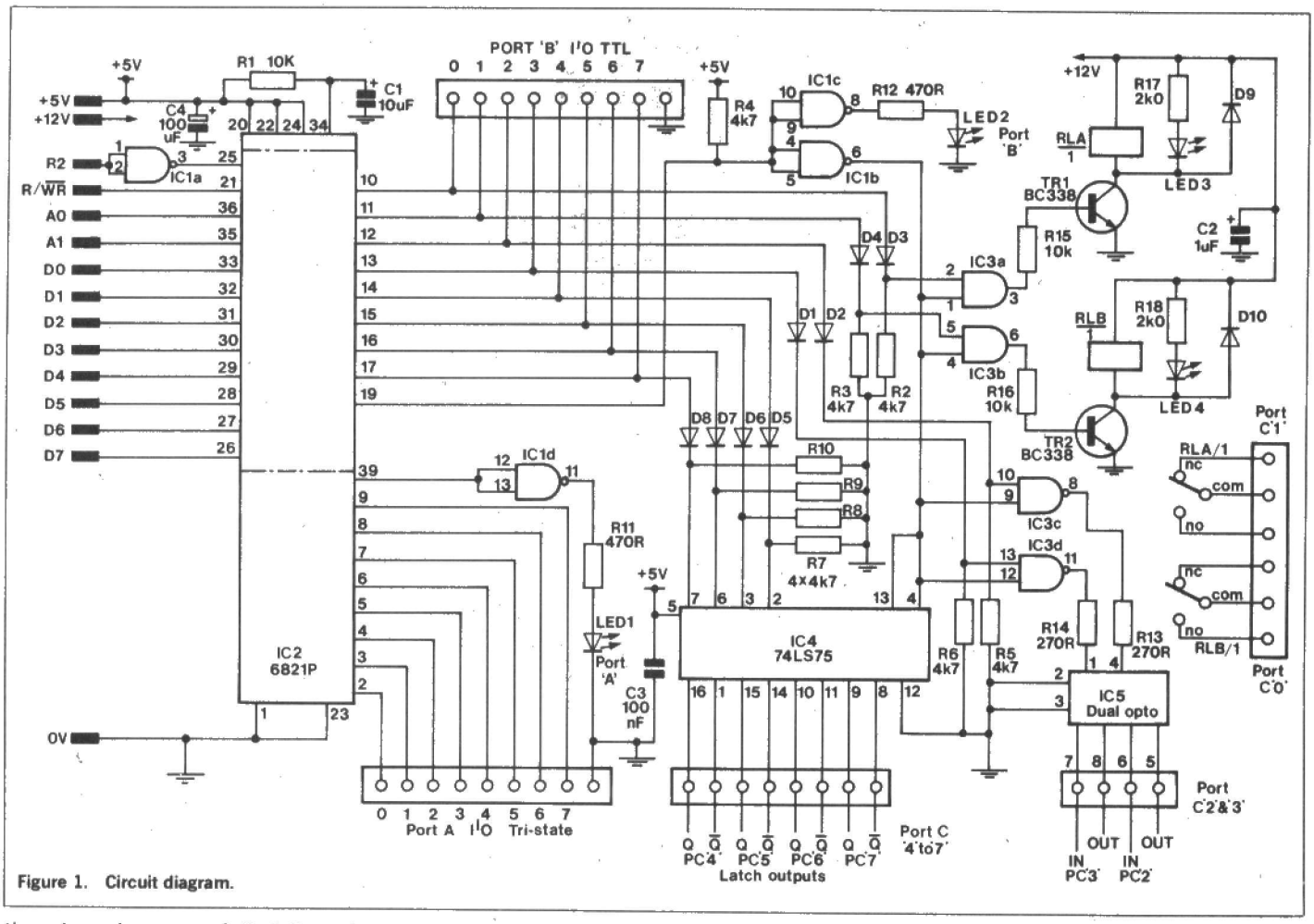


Figure 1. Circuit diagram.

tions have been carefully followed and the module has been correctly built, plug it into the cartridge socket, with component side 2 upwards.

Testing

With a voltmeter set to read 5V DC, connect the negative lead to one of the 0V terminals on port A or B, and the positive lead to pin 14 of IC1. Switch on the Dragon, and a reading of +5V should show that the supplies are correct. Wait a few seconds for the display to appear and confirm that all is well so far. If this does not happen, switch off immediately and remove the module, check that the computer is functioning correctly.

Type POKE 49155, 48 ENTER and LED 2 will operate. Type POKE 49153, 32 ENTER and LED 1 will operate. POKE either of these addresses with Ø to extinguish the LEDs. With all four LEDs off, type POKE 49155,52:POKE49154,1 ENTER. LEDs 2 and 3 will operate, along with RLA.

Type POKE 49154,2 ENTER. LED 3 will go out and LED 4 will operate, RLA release and RLB operate. To check that both relays are working, use a meter set to ohms x 1 between COMM and NO or NC on port C, PCØ and PC1. RLA contacts are at PCØ and RLB contacts at PC1.

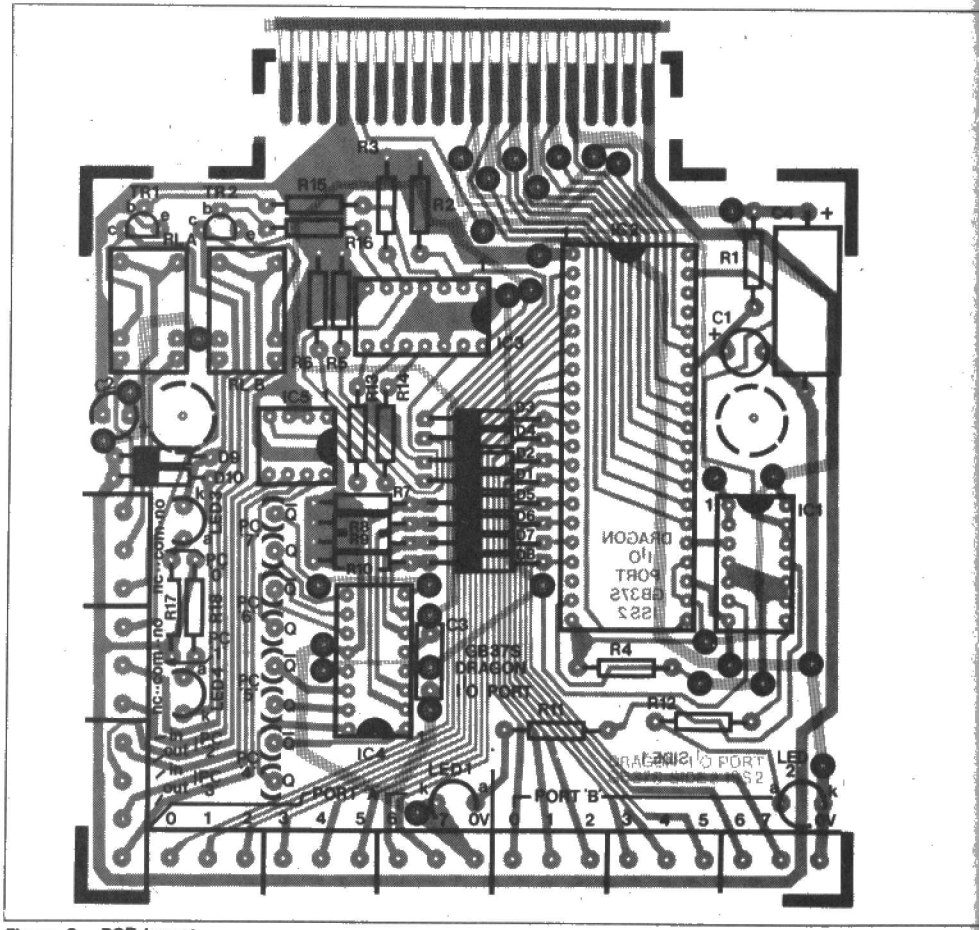


Figure 2. PCB layout.

TABLE 1. PORT C

DATA CODE	PC0 RLA	PC1 RLB	PC2 OPT	PC3 OPT	PC4 Q	PC4 Q1	PC5 Q	PC5 Q1	PC6 Q	PC6 Q1	PC7 Q	PC7 Q1
0	0	0	0	0	1	0	1	0	1	0	1	0
1	1	0	0	0	1	0	1	0	1	0	1	0
2	0	1	0	0	1	0	1	0	1	0	1	0
4	0	0	1	0	1	0	1	0	1	0	1	0
8	0	0	0	1	1	0	1	0	1	0	1	0
16	0	0	0	0	0	1	1	0	1	0	1	0
32	0	0	0	0	1	0	0	1	1	0	1	0
64	0	0	0	0	1	0	1	0	0	1	1	0
128	0	0	0	0	1	0	1	0	1	0	0	1

1=+5V OR 'ON', 0=0V OR 'OFF'

```
PROGRAM 1.

1 CLS
2 PRINT@5,"DRAGON I/O PORT TEST":PRINT
3 INPUT"ENTER PORT (A,B OR C)";P$
4 IFP$<"A"OR P$>"C"THEN3
5 INPUT"ENTER MODE(IN OR OUT)";M$
6 IFM$="IN"AND P$="C"THEN5
7 IFM$="IN"OR M$="OUT"THEN8 ELSE5
8 CLS0:PRINT"PORT-";P$;"-";M$;"PUT"
9 REM PORT CODES
10 IFP$="A"THENP=49153:N=36
11 IFP$="B"THENP=49155:N=4
12 IFP$="C"THENP=49155:N=52
13 IFM$="IN"THEN20
14 REM PORT A-C O/P
15 POKE P,0:POKE P-1,255:POKE P,N
16 GOSUB27
17 PRINT@32,"":INPUT"ENTER DATA(0-255)";D$
18 IFD$="P"THEN POKE P-1,0:POKE P,0:GOTO1
19 D=VAL(D$):POKE P-1,D:GOTO17
20 REM PORT A,B I/P
21 POKE P,0:POKE P-1,0
22 POKE P,4:POKE P-1,0
23 PRINT@20,"DATA="
24 GOSUB27
25 GOSUB28
26 GOTO1
27 PRINT@448,"**** ENTER P TO RE-SELECT ****":RETURN
28 A$=INKEY$:IFA$=""THEN  PRINT@25,PEEK(P-1):GOTO28
29 RETURN
```

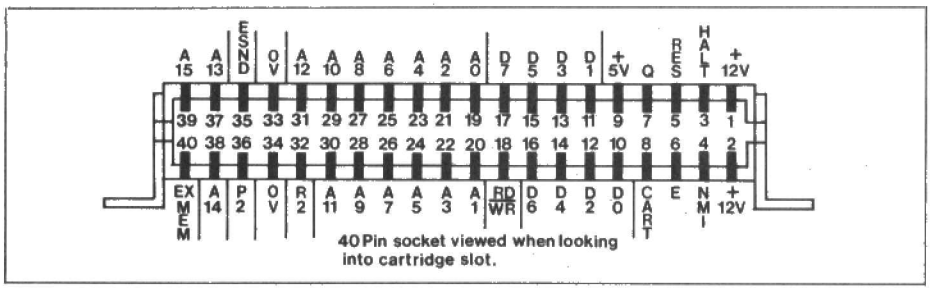
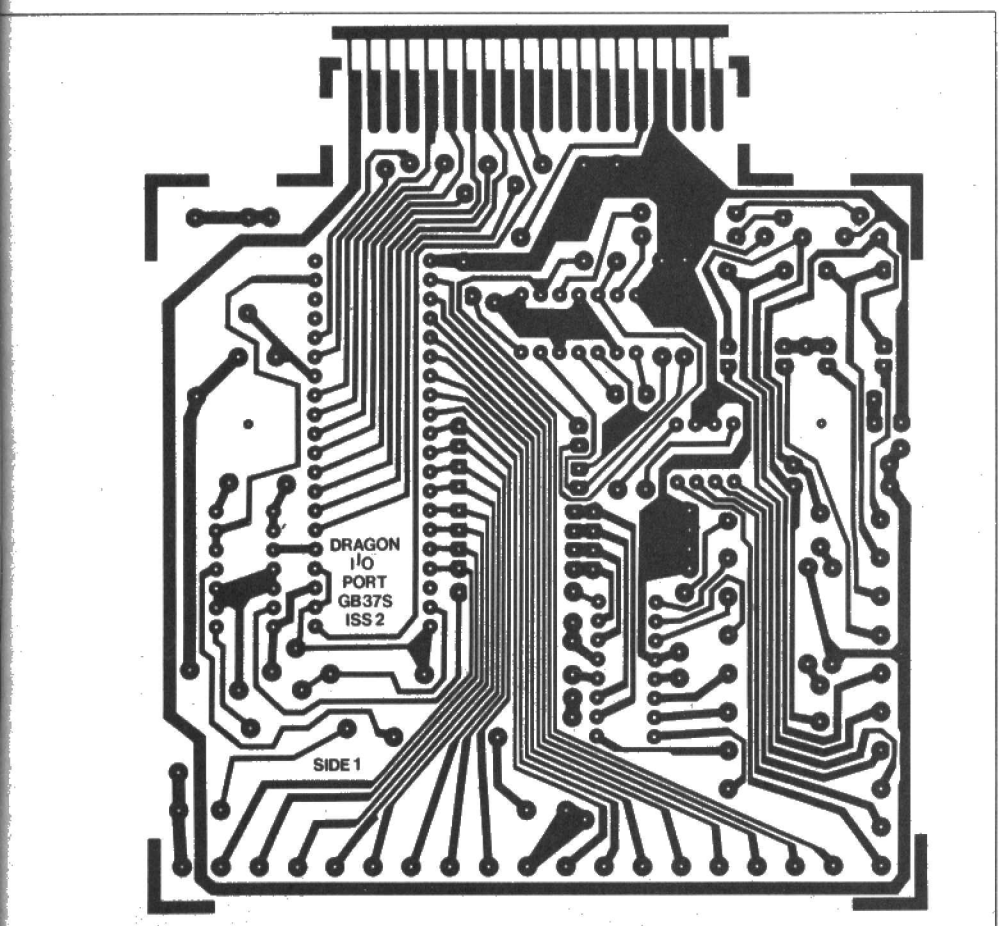


Figure 3. Dragon cartridge socket pinouts.



Opto ports PC2 and PC3 are checked by connecting an ohmmeter across the In/Out terminals of PC2 and typing POKE 49154,4. The In terminal is the positive input to the opto isolator, so connect the negative lead of your ohmmeter to this terminal and the positive lead to the Out terminal. This may appear to be contradictory, but is necessary because on most multimeter ohm ranges the internal battery positive appears at the negative terminal, due to switching arrangements. Full on resistance is about 200ohms. Type POKE 49154,8 to turn PC2 off and PC3 on. Repeat the meter check to PC3. Maximum off resistance is extremely high, and may be considered to be open circuit. POKE 49154 with Ø to turn off PCØ-3.

When using opto-isolators, note that they function as a low current switch and can only handle up to 20V at 8ma. Higher currents, up to 25mA at 5V can be switched providing that the load does not exceed 150mW.

Both relays can switch up to 1A at 100V or 24V DC, but will not handle mains voltages.

Port C, PC4 to PC7, when enabled will follow PB4-7 on the Q outputs and their inverse on the $\overline{Q}$ outputs. If port C is disabled the outputs will remain latched until reaccessed. Outputs are TTL levels, 0V to 4V approximately.

Table 1 lists the various options available at port C and the data codes (Ø to 255) used for operating them.

To keep the operation of IC2 as simple as possible a list of routines used for accessing each port appears at the end of this article. For further information, comprehensive data

sheets for the 6821 are available, but are really only for technically minded constructors.

Type in Program 1 to continue testing the port, RUN and ENTER. The program asks for a port to be entered, so enter A. Enter OUT mode. Connect the voltmeter to PAØ and 0V, then enter 1. This should give a reading of +4.5V. Repeat this on pins PA1 to 7, entering data codes 2,4, 8, 16, 32, 64, and 128. Only one PA output should be high, the others should be at 0V. Obviously, any decimal code from Ø to 255 could be entered, and the binary coded output calculated, then checked with the meter on port A.

Enter the program again, this time selecting port A,IN. The display is slightly different and input data is required, to be read and printed after

```
    ACCESS ROUTINES
  PORT A
 --------
POKE 49153,0    (CONTROL REGISTER)
POKE 49152,N    (DATA DIRECTION REGISTER)
POKE 49153,4    (ACCESS OUTPUT REGISTER
POKE 49152,DATA (0-255 WRITE)
 OR PEEK(49152) (0-255 READ)

  PORT B
 --------
POKE 49155,0    (CONTROL REGISTER)
POKE 49154,N    (DATA DIRECTION REGISTER)
POKE 49155,4    (ACCESS OUTPUT REGISTER)
POKE 49154,DATA (0-255 WRITE)
 OR PEEK(49153) (0-255 READ)

  PORT C(AND B)
 ---------------
POKE 49155,0
POKE 49154,255  (OUTPUT MODE)
POKE 49155,52   (ENABLE PORT C)
POKE 49154,DATA (0-255)

N=BITS 1 TO 8 ON(1) FOR OUTPUT MODE
OR BITS 1 TO 8 OFF(0) FOR INPUT MODE

  LED 1 (PORT A)
 ----------------
POKE 49153,32

  LED 2 (PORT B/C)
 ------------------
POKE 49155,48
```

DATA=. Because port A is tri-state, a no input reading of 255 (PAØ-7 = high) is shown. Connect PAØ to 0V and data will be 254, or 255 - 1. Remove 0V from PAØ and reconnect to PA1. This time DATA= 253 or 255-2. Repeat tests on PA2 to PA7 in turn and check DATA=251,247, 239, 223, 191 and 127.

Type P, followed by B,IN and ENTER. Unlike port A, these inputs are normally low so connect PBØ to +5V for DATA=1. Repeat on PB1 to 7 for DATA= 2,4,6,8,16,32,64 and 128, or try different combinations as before.

By now, the module should be working correctly and be ready for use. If not, there may be edge connector problems, or the PCB may require further support. Fault-finding may be performed with the aid of a voltmeter and the access routines.

PARTS LIST DRAGON I/O PORT

Resistors – All 0.4W 1% metal film unless specified

R1,15,16	10k	3 off	(M10K)
R2-10	4k7	9 off	(M4K7)
R11,12	470R	2 off	(M470R)
R13,14	270R	2 off	(M270R)
R17,18	2k0	2 off	(M2K0)
Capacitors			
C1	10uF 16V Tantalum		(WW68Y)
C2	1uF 35V Tantalum		(WW60Q)
C3	100nF Disc		(BX03D)
C4	100uF 25V axial electrolytic		(FB49D)
Semiconductors			
D1-8	1N4148	8 off	(QL80B)
D9,10	1N4001	2 off	(QL73Q)
TR1,2	BC338	2 off	(QB69A)
IC1	74LS00		(YF00A)
IC2	6821P		(WQ46A)
IC3	74LS08		(YF06G)
IC4	74LS75		(YF32K)
IC5	Dual opto		(YY62S)
LED1,2	Red LED	2 off	(WL27E)
LED3,4	Mini Red LED	2 off	(WL32K)
Miscellaneous			
	P.C. board		(GB37S)
RL A,B	Relay ultra min SPDT	2 off	(YX94C)
	3-way P.C. terminal	8 off	(RK72P)
	4-way P.C. terminal		(RK73Q)
	D.I.L. socket 40 pin		(HQ38R)
	D.I.L. socket 16 pin		(BL19V)
	D.I.L. socket 14 pin	2 off	(BL18U)
	D.I.L. socket 8 pin		(BL17T)
	Trackpin	1 pkt	(FL82D)
	Veropin 2145	1 pkt	(FL24B)
	Feet cab	1 pkt	(FW19V)
	Bolt 4BA ¼"	1 pkt	(BF02C)
	Nut 4BA	1 pkt	(BF17T)

A complete kit of all parts is available. Order As LK18U Price £13.95.

Interfacing the BBC Micro *Continued from Page 22*

Handshake Lines

The two handshake lines of each port provide similar facilities to those of the user port, but there is no independent input mode, and there are differences in the way in which they are set up and used. As inputs, the handshake lines can either set their respective interrupt outputs low on an active transition, or they can be used with these outputs disabled. We will only consider the A port, but the B port is used in the same way. CA1 is controlled by bits 0 and 1 of control register A, and its output is at bit 7 of this register. CA2 is controlled by bits 3 to 5 and gives an output at bit 6. The logic AND facility of the computer can be used in the way described earlier to test the state of the just bit 6 or bit 7 of the control register. Table 1

Binary/ Decimal No.	Mode Of Operation
00/0	CA1 high to low, interrupt disabled
01/1	CA1 high to low, interrupt enabled
10/2	CA1 low to high, interrupt disabled
11/3	CA1 low to high, interrupt enabled
000/0	CA2 high to low, interrupt disabled
001/8	CA2 high to low, interrupt enabled
010/16	CA2 low to high, interrupt enabled
011/24	CA2 low to high, interrupt enabled

Table 1

ADDRESS	RS1	RS0	CONTROL REGISTER BIT 2	REGISTER SELECTED
&FCC0	Low	Low	High	Peripheral Register A
&FCC0	Low	Low	Low	DDRA
&FCC1	Low	High	Irrelevant	Control Register A
&FCC2	High	Low	High	Peripheral Register B
&FCC2	High	Low	Low	DDRB
&FCC3	High	High	Irrelevant	Control Register B

Figure 4. 6821 addresses.

details the way in which the various input modes are obtained.

Note that CB2 is different to CA2 when it is used as an output in that in the first mode it is reset by a write operation, and in the pulse mode the pulse is produced when writing to the port.

Often both handshake lines will be used, and then the number written to ?&FCC1 or ?&FCC3 is the sum of the two decimal numbers in the above tables which give the desired operating modes. Remember to add a further 4 to this figure if access to the port (rather than the DDR) is needed.

In this article it has been assumed that the input and output devices will be directly addressed, but Acorn recommend the alternative method of using OSBYTE calls. This is simply because directly addressing peripheral devices will not work if one of the second processors is added to the Tube. It is possible to write to an output port using a *FX command (*FX151,96,255 writes 255 to the user port DDR for example), but it is not possible to send a numeric variable in this way, or to read from a peripheral device. It is

Table 2 shows the various ways in which CA2 can be used as an output.

Binary/ Decimal No.	Mode of Operation
100/32	set high by activating CA1, low by read operation
101/40	high to low pulse during read operation
110/48	constant low output
111/56	constant high output

Table 2

possible to read from an input port using a machine code routine, as described in the "User Manual" (but note that this stores the answer in the Y register and not in the accumulator). It is much easier to directly address peripheral devices, and is probably not worthwhile using the OSBYTE calls unless it is essential to do so.

The 12 bit analogue to digital converter of the BBC micro is very useful for application where a fast sampling rate is not needed. It is quite simple to use and is fully described in the "User Guide".

COMING SHORTLY

- An ORIC Talkback
- Personal Stereo Dynamic Noise Limiter
- Syndrum Interface
- Microphone Pre-amp/Limiter
- Pseudo Stereo AM Radio
- NiCad Charger Timer
- Spectrum I/O Port
- TTL/RS232 Converter
- 1K ZX81 RAM Extension
- Part 2 of the Telephone Exchange
- VIC Extendiboard with 3K RAM Pack
- Logic Pulser
- Frequency Meter Adaptor
- An Auto-Waa pedal
- A Spectrum Keyboard
- Part 2 of the House Wiring Article

CORRIGENDA

Vol. 2 No. 5

Modem: R4b should be 12k.

Vol. 2 No. 7

VIC20 RS232 INTERFACE: Since this project was published, a few improvements have been made.

R4,8,12 and 16 are now 4k7.

Four extra resistors (R33-36 inc.) value 4k7, have been added to each of the input lines Sin, DCD, CTS and DSR.

The power supply section of the circuit has been redesigned, see sketch below. C3 is a 100uF Reversolytic, R37 is a 47R ½W Standard resistor and D5 to 7 are IN4001.

Note: The PCB (GB28F) has been modified to accept these new components and the kit (LK11M) has the new parts supplied.

SIMPLE SWEEP OSCILLATOR: Some components in the PARTS LIST have been changed.

C4,6,7,8 are now 100uF 25V P.C. Electrolytics (FF11M).

C11 is 220nF polyester (BX78K).

4 DIL sockets 8 pin (BL17T) are required, and 2 DIL sockets 16 pin (BL19V) are needed.

Note: The Kit (LK06G) contains these parts.

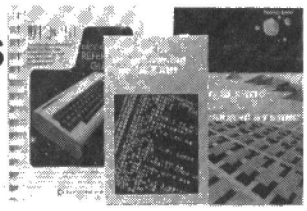
CMOS CRYSTAL CALIBRATOR: In the PARTS LIST, TR2 should be BC108 not EC108.

ENLARGER TIMER: In Figure 4, the pin out designated 2N6073 should be uA 78L12AWC and vice versa.

Price list of new items in this issue

BK68Y	SPCO Nonlock Switch	**£1.99**
BK71N	10mm Cap Green	**6p**
BK72P	Membrane Switch	**£9.64**
BK73Q	Flat Flex Connector 7-way	**62p**
BK77J	Synchime Front Panel	**£1.25**
BK79L	0.156" 2 x 22 Way P.C. Edgecon	**£3.50**
FG23A	2 x 28-Way P.C. Edgecon	
B20W	Doorbell P.C.B.	**£1.92**
GB25C	Code Lock P.C.B.	**£2.92**
GB29G	Dragon RS232 Interface P.C.B.	**£3.62**
GB30H	Probe Upper P.C.B.	**98p**
GB31J	Probe Lower P.C.B.	**98p**
GB37S	Dragon I/O Port P.C.B.	**£2.95**
GB38R	Synchime P.C.B.	**£1.20**
GB42V	Spectrum RS232 Interface P.C.B.	**£3.95**
LK09K	Mini-lab Kit	**£32.50**
LK12N	Dragon RS232 Interface Kit	**£13.75**
LK13P	Logic Probe Kit	**£9.95**
LK14Q	Code Lock Kit	**£19.98**
LK15R	Synchime Kit	**£10.90**
LK18V	Dragon I/O Port Kit	**£13.95**
LK21X	Spectrum RS232 Interface Kit	**£17.95**
QY54J	Low Current Display	**£2.89**
QY55K	MC 14419	**£3.86**
QY57M	2716/M7	**£8.50**

MAPLIN'S TOP TWENTY BOOKS



1. (3) De Re Atari (WG56L) (cat. P62)
2. (2) Games for the Atari by S. Roberts (WA47B) (cat. P62)
3. (1) Audio Circuits and Projects by Graham Bishop (XW46A) (cat. P41)
4. (4) Cost Effective Projects Around the Home by John Watson (XW30H) (cat P41)
5. (6) Projects for the Car and Garage by Graham Bishop (XW31J) (cat. P30)
6. (11) Remote Control Projects by Owen Bishop (XW39N) (cat. P43)
7. (—) Understanding Telephone Electronics by George L. Fike and George E. Friend (WK45Y) (see note)
8. (5) Master Memory Map (XH57M) (cat. P62)
9. (10) Electronic Security Devices by R. A. Penfold (RL43W) (cat. P40)
10. (8) The 6809 Companion by M. James (WG88V) (cat. P63)
11. (16) The TTL Data Book (WA14Q) (cat. P33))
12. (17) Programming the 6502 by Rodnay Zaks (XW80B) (cat. P54)
13. (7) VIC Programmers Reference Guide (WA33L) (cat. P63)
14. (19) How to Use Op-Amps by E. A. Parr (WA29G) (cat. P35)
15. (13) Atari BASIC Learning by Using by Thomas E. Rowley (WG55K) (cat. P62)
16. (—) Radio and Electronics Colour Codes and Data Chart (RH05F) (cat. P30)
17. (15) Electronic Synthesiser Projects by M. K. Berry (XW68Y) (cat. P50)
18. (12) Power Supply Projects by R. A. Penfold (XW52G) (cat. P38)
19. (9) The BBC Micro — An Expert Guide by Mike James (WK04E) (cat. P63)
20. (—) VIC Revealed by Nick Hampshire (WA32K) (cat. P63)

These are our top twenty best selling books based on mail order and shop sales during April, May and June 1983. Our own publications and magazines are not included. We stock over 500 different books to do with electronics and computing and the full range is shown on pages 29 to 65 of the 1983 catalogue, page 15 of issue 6, pages 60 and 61 of issue 7, and of course the new books section of this magazine.

Note: For full details of WK45Y please see page 60 of issue 7 of this magazine.

NEW ITEMS PRICE LIST *Continued from page 37*

Sword of Fargoal **(+16K) 1C-KK09K** **£20.75**
Tank Arcade **1C-KH18U** **£11.95**
Typo **1E-KK18U** **£29.95**

CONNECTORS
BK74R 0.156in 2 x 12 way PC Edgcon **Price £2.36**

HEATHKIT
HK01B Digital Digital Alarm Clock **Price £34.95**
HK02C Informer Alarm **Price £69.95**
HK03D Infra-Red Alarm **Price £149.95**
HK04E Electronics for Hobbyists **Price £64.95**
HK05F DC Electronics Course **Price £49.95**
KH06G AC Electronics Course **Price £54.95**
HK07H Semiconductor Electronics Course **£54.95**
HK08J Electronic Circuits Electronic Course **£64.95**
HK09K Test Equipment Course **Price £64.95**
HK10L Experimenter Trainer **£74.95**
HK11M Assembled Trainer **Price £159.95**
HK12N Digital Techniques Course **Price £79.95**
HK13P Digital Techniques Trainer **Price £89.95**
HK14Q Assembled Digital Techniques Trainer **Price £169.95**
KH15R Microprocessor Course **Price £99.95**
HK16S Interfacing Micros Course **Price £99.95**
HK17T Advanced Micro Course **Price £99.95**
HK18U Microprocessor Trainer **Price £189.95**
HK19V Assembled Microprocessor Trainer **£329.95**
HK20W Hero Robot **£1,599.95**
HK21X Robotics course **Price £99.95**
HK22Y Practice Oscillator **Price £24.95**
HK23A Dip Meter **Price £79.95**
HK24B Cantenna Dummy Load **Price £29.95**
HK25C Antenna Coax Switch **Price £24.95**
HK26D RF Oscillator **£54.95**
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XG30H Echo Machine EM-006 **£55.00**

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BK67X Moisture Scale **Price £0.20**
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GB09K Modem Main PCB **Price £5.20**
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GB12N Inverter PCB **Price £1.99**
GB13P Scratch Filter PCB **Price £2.20**
GB14Q ZX81 TV Sound/Inverse Video PCB **Price £2.20**
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GB19V DX'ers Audio Processor PCB **Price £1.90**
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LK00A VIC20 Talkback Kit **Price £24.95**
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LW98G Programmable Timer Kit **Price £8.45**
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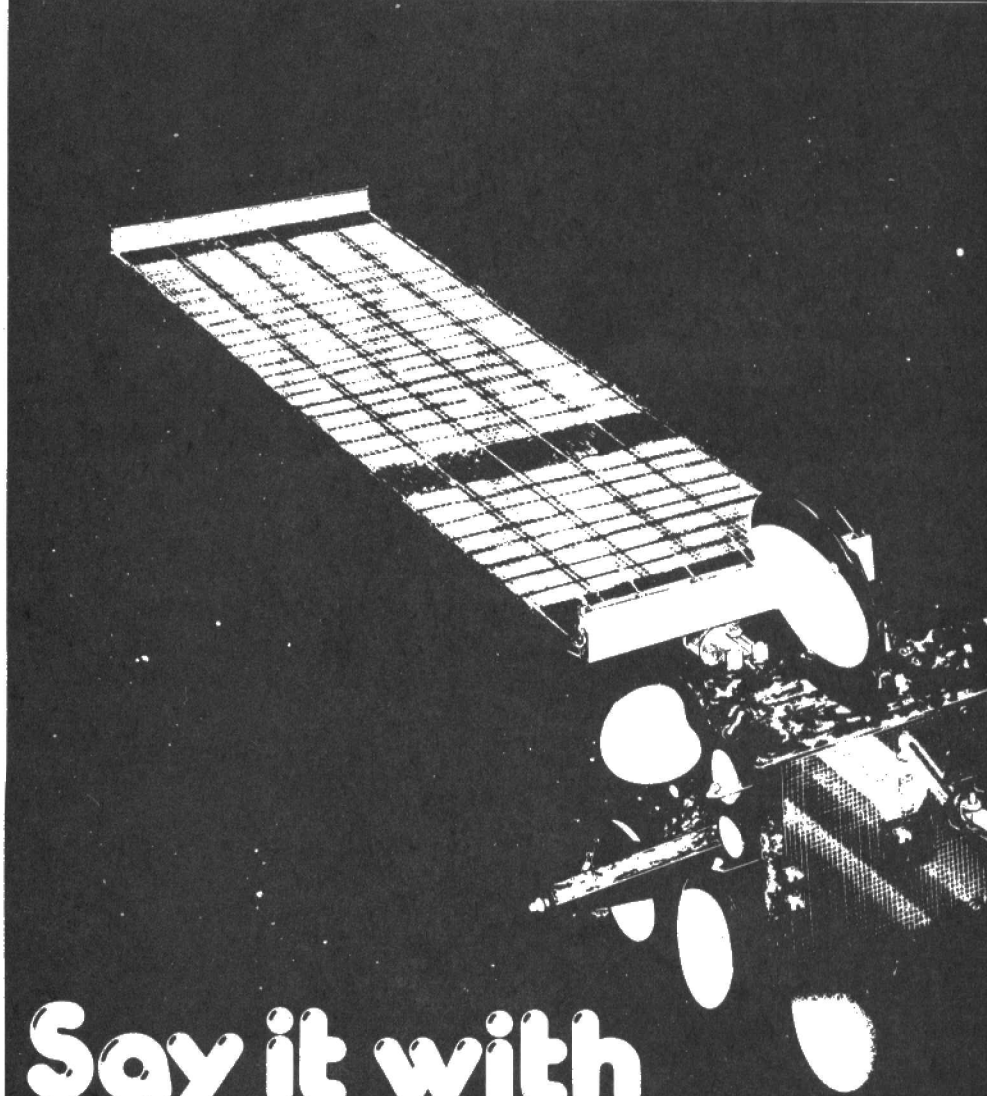
QY50E SP0256 **Price £11.98**
QY52G 2716/M6 **Price £8.50**
QY53H BF173 **Price £0.41**

WOUND COMPONENTS
XG29G Inverter Transformer **Price £22.50**



Say it with SATELLITES

by Mike Wharton

Ups and Downs

It is usually only the more interesting space shots which attract the attention of the news media. This often gives the impression that satellite launches are few and far between, with perhaps the odd Space Shuttle launch now and then. Nothing could be further from the truth, for there are many launches of all manner of craft throughout the year. Most of these are put up by the Big Two, America and Russia, but quite a few launches are made by countries such as Japan, India and, of course, Britain. Some indication of the numbers involved may be obtained from the following; in December of last year the Russians launched seven satellites of various types, and of the total of 121 launches during 1982, 101 were Russian, 18 from the USA, 1 from Japan and 1 from China.

Most of the Soviet satellites were military in nature, ranging from the surveillance devices mentioned in a previous issue to communications satellites. Such activity is not an unusual event, for during January of this year, the Russians launched another four rockets; one of these is particularly interesting, since it carried aloft a batch of no less than eight small military communications satellites.

It should be no surprise to find the Japanese active in the business of satellites, and doubtless they see it as another area to exploit with their usual acumen. The first Japanese satellite launched in 1983 was a communications satellite, launched from the Tanegashima Space Centre near Takazaki on the 4th February. This was followed by an astronomical satellite, Astro-2, launched on the 20th February from the Kagoshima Space Centre. This last satellite will be used for detecting and monitoring celestial X-ray sources.

With all these satellites going up it is not surprising that there are many that come down. Some of these come down of their own accord, due to the decay of a relatively low orbit, whilst some are brought down deliberately. These, of course, are the military surveillance satellites which are recovered in order to retrieve the information they contain without divulging the contents by transmitting it over a radio link. During December 1982 and January and February 1983, fourteen space-craft were recovered or re-entered, most of them of Russian origin.

Amateur Satellites

Many radio Hams will be waiting with anticipation for the launch of the latest amateur satellite, the so-called Phase 3-B, aboard the Ariane launch vehicle. Some readers may recall that the last attempt to use this launcher to put a payload aloft ended with the whole lot splashing down in the Atlantic. This was attributed to a breakdown in the third stage turbo-pump. As a consequence, the launch of the next mission has been put back while this component is rigorously checked over in order ensure that there is no repetition of such an expensive failure. The amateur satellite will again be going as a 'piggy-back' payload, the main satellite in this case being the European communications satellite, ECS-1.

If this launch proves to be successful, and by the time you read this it should have gone, then another satellite will be available for amateur use, which will then be known as OSCAR 10.

The prior satellite to this one, OSCAR 9, is still not completely out of the woods. This 'bird' is rather different from other amateur satellites, in that it carries scientific experiments and no transponders. A transponder is a sort of space repeater, used for re-transmitting radio signals over large distances. Unfortunately, complete control has not been regained since it came back on the air, and it must be feared that its orbit will decay beyond the point of no return before it is able to realize its full potential.

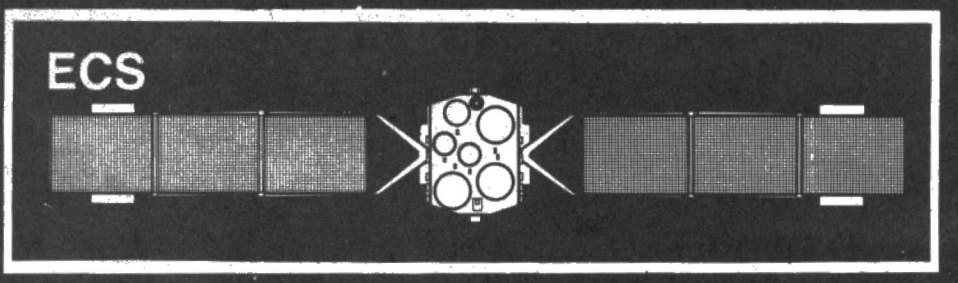
Space Astronomy

The number of satellites dedicated to research from the vantage point of space continues to increase. During May this year a satellite was launched by the European Space Agency, ESA, to study distant X-ray sources. Called EXOSAT, its two-year mission will be to observe some of the most unusual and violent events in the known Universe. For example, it is intended to be used to examine the disappearance of matter into 'black holes' as well as the massive out-pouring of X-rays from some of the remote radio galaxies. One particular feature of this craft is its ability to be pointed at these sources to an accuracy of one thousandth of a degree of arc, which is claimed to be some fifty times better than hitherto achieved.

Another similar space-craft, but one which is observing a completely different part of the electro-magnetic spectrum, is the Infra Red Astronomical Satellite, IRAS. A recent achievement of this craft was the detection of a comet, which eventually became visible to the naked eye; in recognition of this the comet was named IRAS-Araki-Alcock. This craft was mentioned in a previous article, and the supply of liquid helium used to cool the infra-red sensors seems to be holding up well and it has provided a great deal of information to astronomers on this part of the spectrum.

Space Shuttle

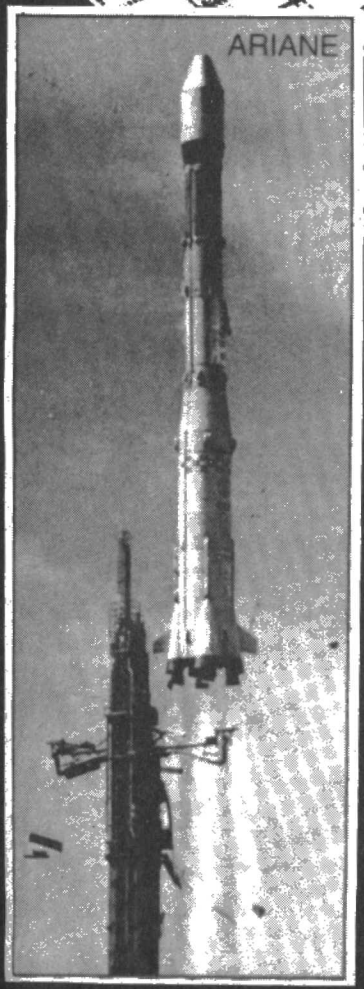
The next scheduled flight of the American Space Shuttle will be in the autumn this year. The primary aim of this flight will be to carry the joint U.S.-European Spacelab aloft. One of the interesting aspects of this flight is that NASA has given the go-ahead for one of the crew, Dr. Owen Garriott, to take an amateur 2-metre band transceiver with him. Thus it will be possible for radio amateurs all over the world to make contact with the call "CQ from W5LFL aboard the Space Shuttle", for W5LFL is Dr. Garriott's amateur call-sign. Exactly how successful this proves to be only time will tell, and certainly one of NASA's stipulations is that any transmissions must not interfere in any way with the planned mission of the Space Shuttle.



DBS-the continuing story

Finally, a few words on the latest developments in Direct Broadcasting by Satellite. This service is the one which is already enjoyed on a somewhat limited basis in some parts of the world, and which is intended to be available in Europe by the end of 1986. The satellite which will carry the TV signals is Olympus (previously L-Sat) presently being built by the British Aerospace Corporation. The U.K. has been allocated five d.b.s. channels in the 12 GHz band and the first two of these will be made available for two new BBC programme services. The three remaining U.K. d.b.s. channels will, no doubt, be allocated in future years. The channel bandwidth available with this system is around 10 MHz, which is appreciably larger than the 5.5 MHz offered by terrestrial transmissions. This has led to suggestions that the extra bandwidth should be used to improve the definition of the system. There are several ways in which this could be done; one method would use the same number of lines and frames as at present, 625 and 50 fields per second, but circuitry in the receiver would store the video information and enable the production of a picture with 1250 lines or 100 fields per second or possibly both. Although there is no more information transmitted, a display with much less line structure and free from flicker could be visually more pleasing. The longer term goal is to transmit true high-definition television (h.d.t.v.), where the picture would actually be generated and transmitted on higher line and field rates, and hence would genuinely contain more information. The difficulty here is that real h.d.t.v. requires a bandwidth of about 30 MHz and is thus beyond the capacity of the presently planned channels in the 12 GHz band.

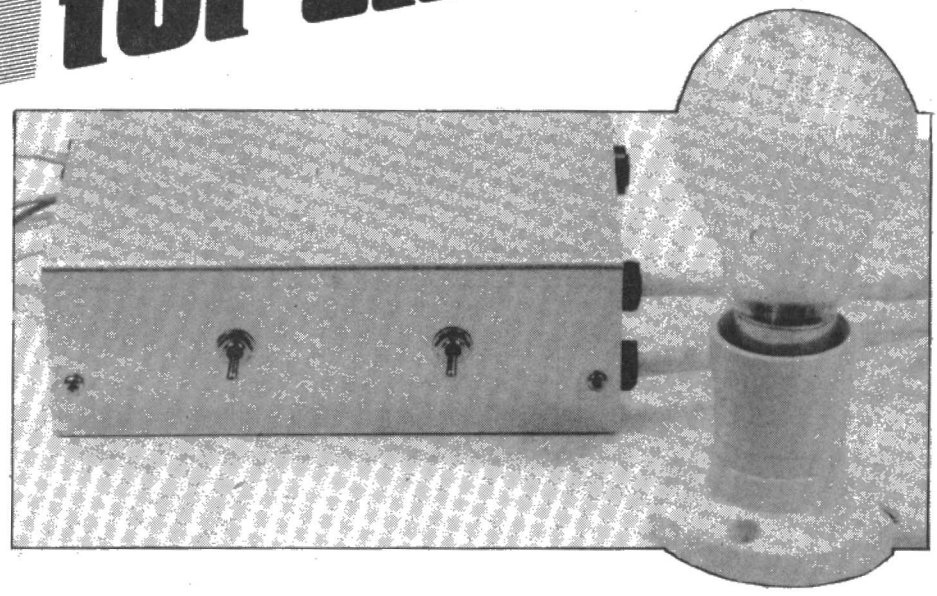
Some may wonder if all this activity is not going to be overshadowed by developments in cable TV. Although cable TV, whether distributed by optical fibre or coaxial cable, does give some freedom from the bandwidth restrictions, the development of such systems must be regarded as a long-term project and as such it is almost impossible to put a time scale on them. On the other hand, satellite TV is almost upon us and is immediately available to everyone, with a suitable TV that is, which cable TV will not be.



★ Attracts attention with or without noise
★ Uses existing doorbell components
★ Simple to instal

Doorbell for the Deaf

by Garfield Dean



For the hard of hearing or the deaf a doorbell is obviously useless. This circuit is an attempt to increase the chance of getting the attention of a deaf person by flashing a light or lights on and off several times in the deaf person's room(s). Also the bell can be made to ring several times for the benefit of anyone who is only hard of hearing and also for the person who pushed the bell switch.

Circuit Description

Figure 1 shows a typical doorbell system. Figure 2 shows the circuit for the doorbell for the deaf which uses all of the existing hardware. There are two 7555 timers, the first of which is in monostable mode with a period of about 2-20 seconds determined by RV1, R2 & C2. When the push switch is pressed, the output of IC1 goes high for 10 seconds and this enables IC2 to work in a stable mode (i.e. oscillate) at a rate of once every two seconds set by C3, R3, R4 & RV2. IC2 turns the relays on and off which in turn switches the bell and lights on and off about 5 or 6 times. A 5A fuse is included in the lighting circuit for safety. S2 disengages the bell relay if, for example, children are sleeping. S1 disengages the light relay if it is necessary that the lights don't flash, e.g. for a photograph. also this allows normal doorbell operation simply by turning S1 off and setting RV1 to give one ring per push. D1 prevents large back EMFs from the relays destroying the rest of the circuit.

Note that the 7555 timer has been used instead of the 555 timer, because of the long time constants involved and for the lower power consumption in standby mode (useful if the circuit is battery operated).

The P.S.U. is the easiest part of the circuit but may need the most careful looking at, depending on the existing doorbell. If you have no doorbell at present or if your doorbell power supply is not suitable (see below) then the circuit for the power supply in figure 3 will work. BR1 rectifies the 8V A.C. and this is then smoothed by C1. IC3, C4 & C5 provide extra smoothing and voltage dropping if required. D2, if fitted, prevents wrong connection by a D.C. supply. With the Maplin transformer the regulator is not used and a wire link is used in the position marked for D2 (Figure 4b).

A suitable supply is:

a) D.C. 9-15V — In this case BR1, C1 and the optional regulator should not be fitted. D2 should be fitted as in figure 4b. Also links should be fitted in place of BR1 as shown in figure 4c. (Note that batteries will run down every 6 months or so, and therefore a transformer may be a better long term solution).

b) A.C. 8-12V — From a Bell Transformer (as this is built for the job). The power supply is built as if using the Maplin transformer; but make sure that

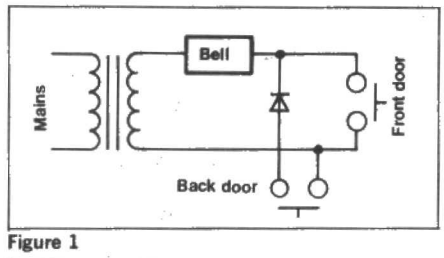


Figure 1

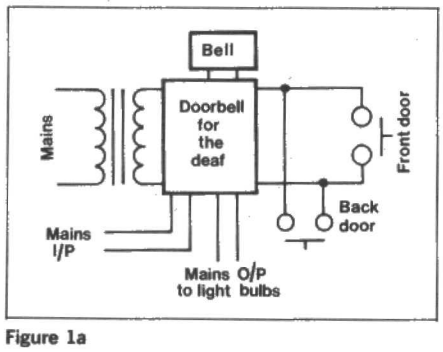


Figure 1a

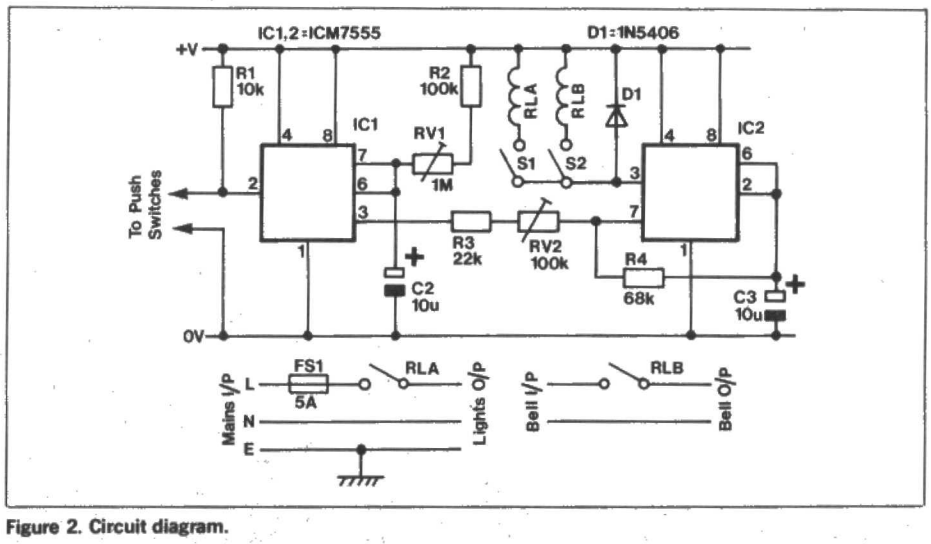


Figure 2. Circuit diagram.

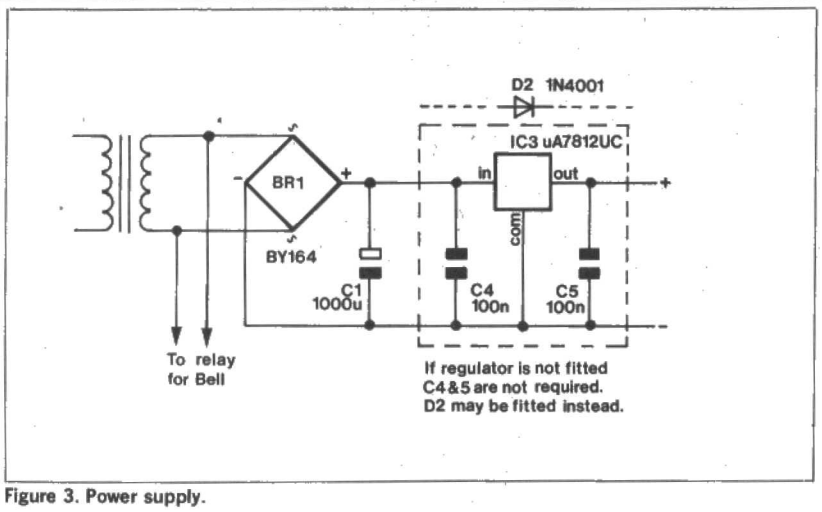


Figure 3. Power supply.

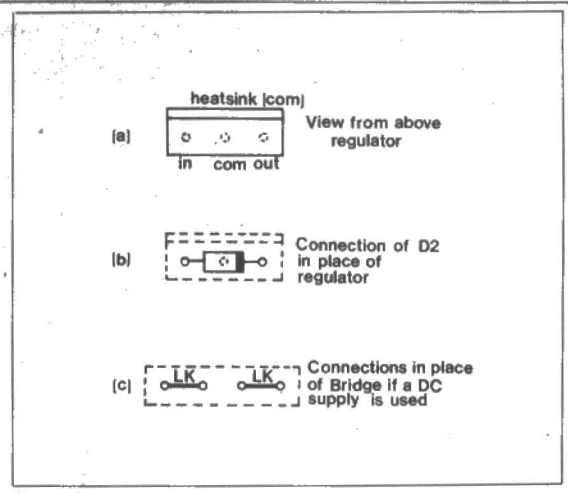


Figure 4.

the connections to the bell (via relay B) come from the pair of transformer windings that the bell was originally connected to.

c) A.C. 12-20V — From a Bell Transformer. The power supply is built as for the Maplin transformer but uses the optional regulator section. Also connections to the bell (via relay B) should come from the pair of transformer tappings that the bell was originally connected to.

Constructional Details

The P.C.B. should be built up as in figure 6 by soldering in components in order of increasing height, inserting veropins into the low voltage output holes. Remember that you will only need to use some of the components listed for your type of power supply.

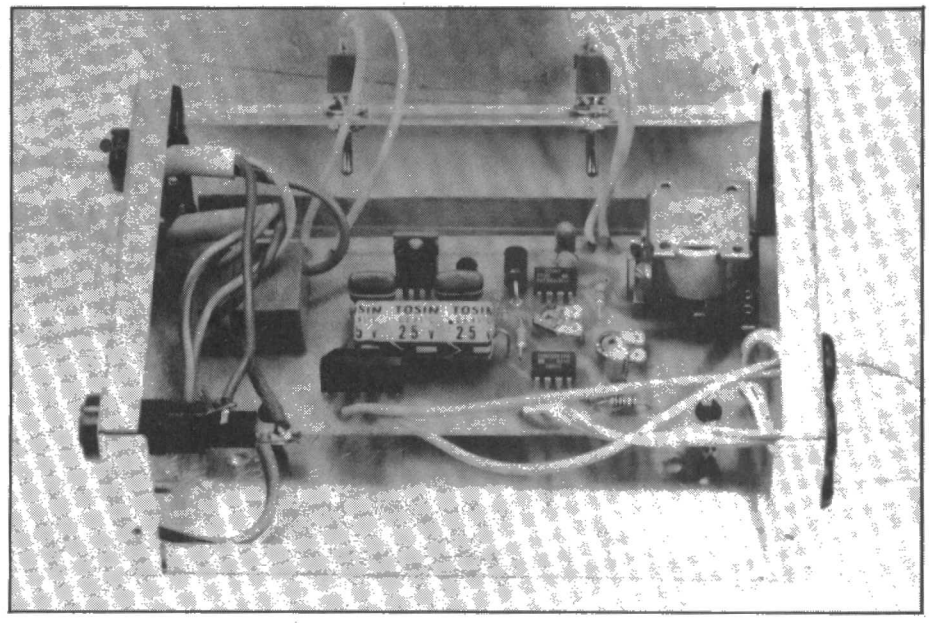
Check the P.C.B. after completion, especially for solder blobs, dry joints and correct polarity of devices; an electrolytic capacitor connected the wrong way round makes a nasty mess when it blows up. The unit is now ready for testing. Temporarily short across each of the two sets of contacts going to the switches S1 and S2.

Put RV1 and RV2 in their mid-positions and temporarily connect the input to the P.S.U. Give a trial push of the doorbell by shorting the two veropins for the bell push together. Both relays should click on and off several times. RV1 adjusts the total length of time the doorbell operates for after a bell push. RV2 adjusts the length of time between individual flashes of the lights (should these need frequent alteration then potentiometers can be used).

If the unit does not work there are 3 main things to check:

1) Is the voltage across IC1 pins 1 and 8 between 9 and 16V? If not then the power supply is at fault.
2) If the output of IC1 does not go high for 2-20 seconds when the bell is pushed, then IC1 or an associated component are at fault.
3) If the output of IC2 does not oscillate between positive and negative supply when IC1 output goes high, then IC2 or an associated component is at fault.

The P.C.B. will now be ready to be fitted into a case. For a functional unit an AB13 case can be used, but for a more attractive finished product a type 215 Verocase should look better. A suggested set of drilling details for an AB13 case are shown in figure 5.



When drilling is complete, fit grommets and the fuse holder where marked and insert the mains wires coming from outside the unit.

Solder these wires directly to the P.C.B., along with an extra earth lead, connected to a solder tag which should be attached to the case with a 4BA bolt and shakeproof washer.

Then fix the P.C.B. down to the case

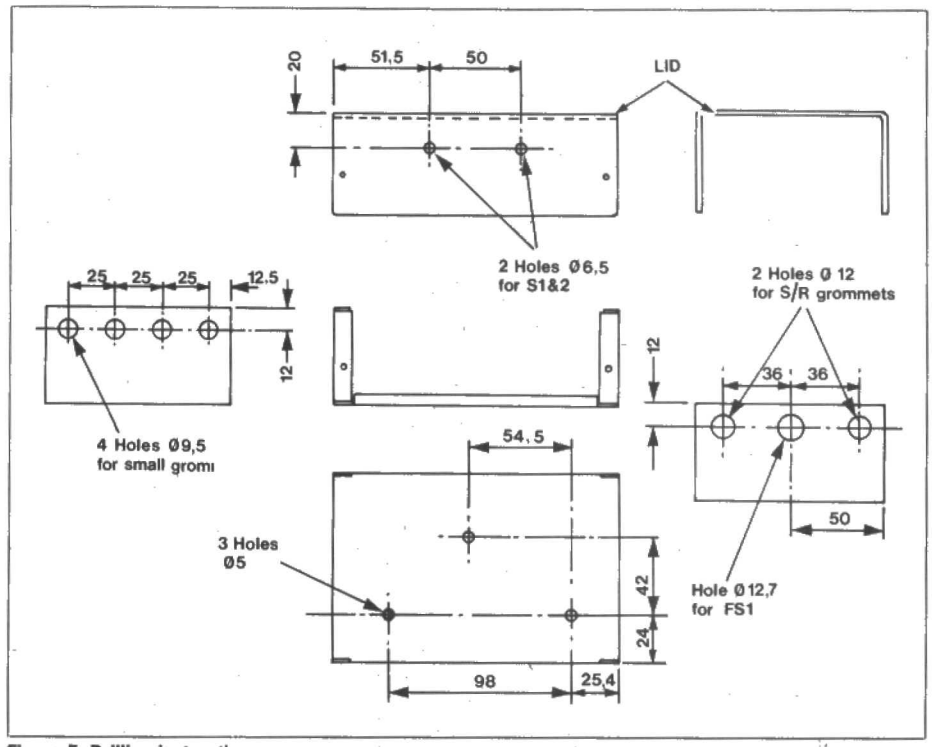


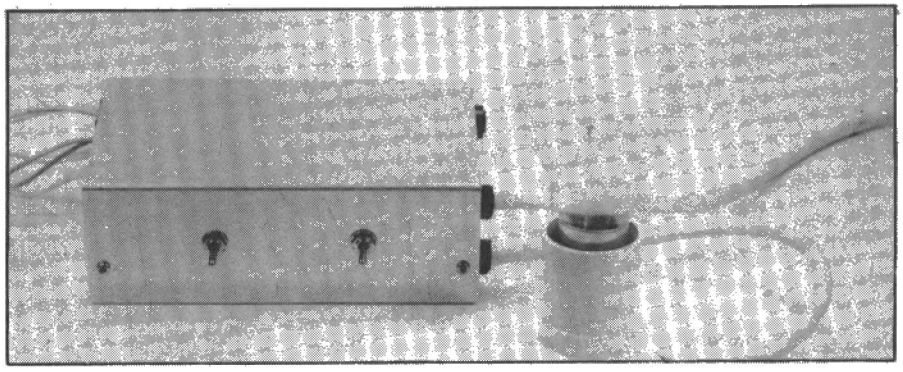
Figure 5. Drilling instructions.

with the 3 P.C.B. stand-offs, or 4BA bolts and metal spacers.

Finally the switches on the front panel and low voltage connections to bell, P.S.U. and bell push can be connected to the P.C.B.

One final point: remember that connections to relay A are at mains voltages, so do not have the mains connected when the case is open for adjustments. Hopefully the unit will now be ready for use.

Good luck!



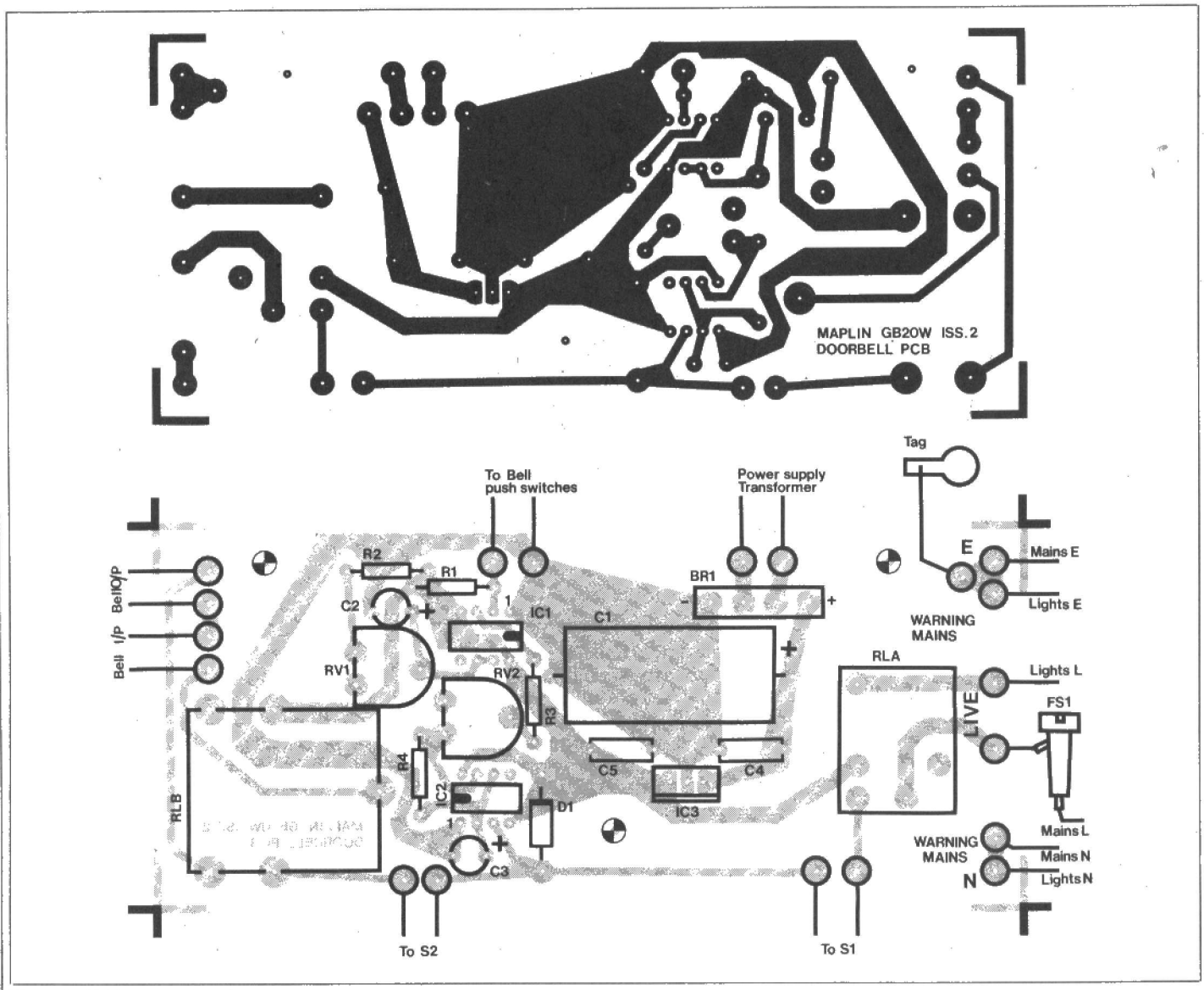


Figure 6. PCB layout and overlay.

DOORBELL FOR THE DEAF PARTS LIST

Resistors — All 0.4W 1% Metal Film			
R1	10k		(M10K)
R2	100K		(M100K)
R3	22k		(M22K)
R4	68k		(M68K)
RV1	1M Hor-sub min Preset		(WR64U)
RV2	100K Hor-sub min Preset		(WR61R)
Capacitors			
C1	1000uF 25V Axial Electrolytic		(FB83E)
C3	10uF 25V Tantalum		(WW69A)
*C4,5	100nF Polyester	2 off	(BX76H)
C2	22uF 16V PC Electrolytic		(FF06G)
Semiconductors			
D1	1N5406		(QL85G)
*D2	1N4001		(QL73Q)
IC1,2	ICM7555	2 off	(YH63T)
*IC3	uA7812UC		(QL32K)
Miscellaneous			
S1,2	Sub-min Toggle A	2 off	(FH00A)
RLA	10A Mains Relay		(YX97F)
RLB	Open Relay 6V		(FX23A)
FS1	Fuse 5A 20mm		(WR07H)
	Safefuseholder 20		(RX96E)
	Grommet small	4 off	(FW59P)
	SR Grommet 6W 1	2 off	(LR49D)
	Stand-off Short	3 off	(FW16S)
*BR1	BY164		(QF43W)
	Doorbell PCB		(GB20W)
	Case AB13		(LF14Q)
	Mains Cable	As reqd	(XR03D)
	Veropin 2141	1 pkt	(FL21X)

If there is no existing doorbell, suitable components are:—

Bell		(FL38R)
Bell Transformer		(FL37S)
Bell Push		(FQ08J)
Bell Push + Nameplate		(FQ09K)
Wire to bell push		(XR39N)

Note components marked * may or may not be used, see text.

FIRST BASE

by Mike Wharton

A Beginner's Guide to Logic Design Part 3

Solution to Problem

If you recall, there was a little problem left for you to sort out in the last section. This was to deduce the Truth Table of an array made up of two-input NAND gates, and the result which you should have arrived at is given in Fig. 1. Comparison of this table with published ones will show it to be that of the Exclusive-OR gate, (EX-OR). The common symbol for this gate, also known as the Difference gate, is shown in Fig. 2a. It is called the Difference gate since a look at its Truth Table will reveal that the output is high only when the inputs are different; the complement of this gate is the Exclusive-NOR gate, (EX-NOR), whose symbol is shown in Fig. 2b. This gate is also known as an Equivalence gate, since its output is high when the inputs are the same, and the Truth Table for this gate is shown in Fig. 3.

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

Figure 1. Derived truth table for 2 input Exclusive OR gate.

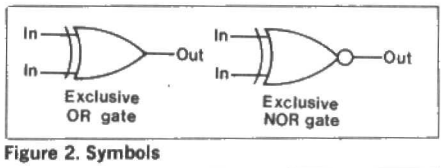


Figure 2. Symbols

A	B	C
0	0	1
0	1	0
1	0	0
1	1	1

Figure 3. Truth table for Exclusive NOR gate

It would be possible to produce an EX-NOR gate by adding an inverter to the output of the previous EX-OR gate made up from NAND gates, thus using a total of five 2-input NAND gates. This would be quite wasteful of gates, and not surprisingly it is possible to obtain both of these devices in a single package. Thus Fig. 4a. shows the pinout of the 7486, a quad 2-input EX-OR gate package, and Fig. 4b. gives the pinout of the 74266, the EX-NOR gate package.

This now completes the list of main logic gates, although there are a few others which

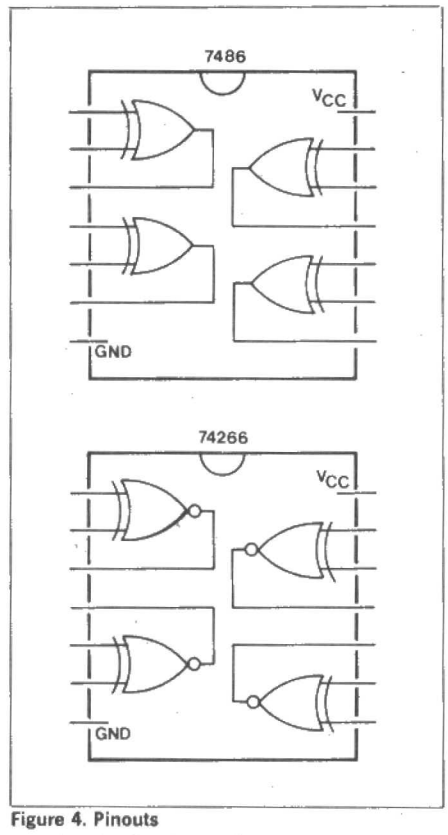


Figure 4. Pinouts

can be obtained, but these really combinations of the above types in order to obtain 'programmable' gates in the one package. An example of this is the 7451 AND-OR-INVERT gate, shown in Fig. 5; here it may be seen that the package contains two AND gates connected to the input of the NOR gate. It is left as an exercise for the reader to derive the Truth Table for this arrangement of gates.

Multi-input gates

So far we have really only concerned ourselves with gates having one or two inputs. Many of the devices available have more than this, as a glance at the relevant pages of the Maplin Catalogue will reveal. For example, the 7430 is an 8-input NAND gate, shown for reference in Fig. 6 along with its Truth Table. Fortunately, this does not make the understanding of these gates that much more difficult. If you look back at the previous Truth Tables, as well as the one for the 8-input NAND gate, you will see that they all have a unique output state. An exception to this rule are the Truth Tables for the EX-OR and EX-NOR gates, which are special cases. The other gates have just one value of logic output for a particular set of inputs; for example, in a 2-input AND gate the output is always low except when both inputs are high. In a 2-input NAND gate, the output is always high, except when both inputs are high, and this follows on for the 8-input NAND gate, where the output is always high except when all the inputs are high.

That this is so can be tested by connecting up a 7430 on a bread-board with a

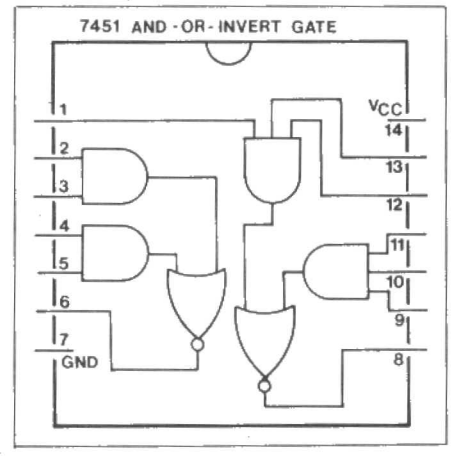
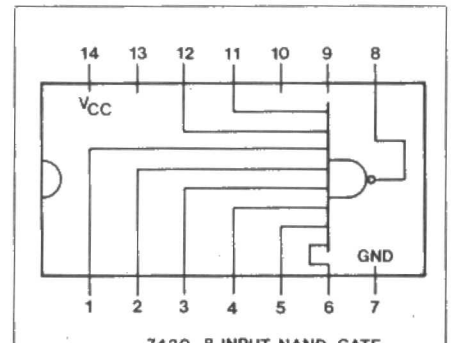


Figure 5. Pinout



7430 8 INPUT NAND GATE

A	B	C	D	E	F	G	H	Q
0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	1
				etc				
0	0	0	0	0	0	0	1	1
1	1	1	1	1	1	1	1	0

Figure 6. Pinout and truth table

LED wired to the output, as shown in the last issue. If each of the inputs is connected to logic 1 then the output will be found to be at logic 0, with the LED extinguished. If one of the inputs is now taken to logic 0, then the LED will light up, and will remain alight while any number of inputs are held at logic 0.

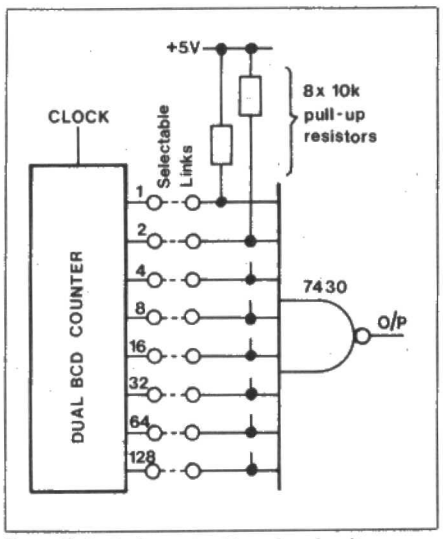


Figure 7. Part of counter/decoder circuit

The use of such a device may be demonstrated by referring to the part of a circuit shown in Fig. 7. The problem here was to produce a signal from the output of the 8-input NAND gate after the counter had counted a selectable number of clock pulses. To achieve this action, each of the inputs is connected to logic 1 by a 'pull-up' resistor, thereby ensuring that the output will be logic 0. The numbers shown by the outputs from the BCD counter are the number of clock pulses which need to be counted before that particular output goes high, assuming a start from zero. Without going into any further detail of how the outputs from the counter would appear, by connecting the appropriate links it is possible to set the circuit to count any value of pulses from 1 to 255. For example, if it were required to count up to 23 clock pulses before a logic 0 appeared at the output of the NAND gate, then the links for 1,2,4 and 16 would be made, since 1+2+4+16=23.

The individual pull-up resistors are needed on the inputs in order to ensure that any unconnected inputs are held at logic 1; the value of these resistors is not all that critical, but it must be remembered that the output of the counter will be required to sink the current through them when it goes low. The BCD counter is a rather different type of animal from the ones we have encountered so far, belonging to the breed of sequential logic devices. This is a whole range of beasties which will be dealt with in a lot more detail in a subsequent article.

Arithmetic Logic Units

Any reader who has perused books or articles on the subject of micro-processors or micro-computers, and these days it's hard to avoid them, may well have come across the term Arithmetic Logic Unit, or ALU. This is the part of the micro-processor which is concerned with 'doing sums' and other logical operations. Needless to say, in a real life processor, this section contains a multitude of functional devices, but it is possible to emulate one of its basic building blocks, the Adder. Side-stepping the old jokes about venomous snakes, the digital adder comes in two types, the half-adder and the full-adder. However, before we delve into the workings of these circuits, it may well be a good idea to brush up on some binary arithmetic.

I am sure everyone reading this is fully conversant with denary arithmetic, that is working in powers of ten. In binary arithmetic the same rules apply, but in this case we are using the number base of two, with the digits 0 and 1. When two denary (or decimal) digits are added together there are two possible situations:

a) a third digit, larger than the other two results, but smaller than the base of the number system, eg,

$$\begin{array}{r} 5 \\ +3 \\ \hline 8 \end{array} \qquad \begin{array}{r} 1 \\ +4 \\ \hline 5 \end{array}$$

The new digit, 8 or 5 in these examples, is called the SUM.

b) the third digit is equal to or larger than the base of the number system,

$$\begin{array}{r} 5 \\ +6 \\ \hline 1\ \ 1 \end{array} \qquad \begin{array}{r} 8 \\ +7 \\ \hline 1\ \ 5 \end{array}$$

CARRY SUM CARRY SUM In this case the position of the digits comes into play and the answer consists of two parts, the SUM and the CARRY. The generation of Sum and Carry occurs whatever number base is in use. In binary addition the generation of Carry bits occurs much more often, as there are only two digits.

$$\begin{array}{r} 0 \\ +0 \\ \hline 0 \end{array} \qquad \begin{array}{r} 0 \\ +1 \\ \hline 1 \end{array} \qquad \begin{array}{r} 1 \\ +1 \\ \hline 1\ \ 0 \end{array}$$

SUM SUM CARRY SUM

These examples cover nearly all the possible combinations of binary addition, the only other one being where the 0 and 1 are reversed in the middle example!

Where binary numbers containing more than one digit are to be added, then the process can be broken down into a series of repeated two-digit additions, until the process is complete. For example:-

$$\begin{array}{r} 10 \\ +01 \\ \hline 11 \end{array} \qquad \begin{array}{r} 111 \\ +010 \\ \hline 1001 \end{array}$$

CARRY SUM In the second example, the addition of the first (right-hand) digits of 0 and 1 gives a Sum of 1, and no Carry; adding the next two digits, 1 and 1, produces a Sum of 0 and a Carry of 1. The next stage is to add together 0, 1 and the Carry; as before 0 and 1 give a Partial Sum of 1, and adding the 1 carried over gives a Sum of 0 and a Carry into the next column. The simple rules of binary addition may be summarised in a Truth Table, shown in Figure 8.

A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Figure 8. Binary addition truth table

Looking at this Table it is possible to see that a Sum OR a Carry is the result of a binary addition, never a Sum AND a Carry. To perform this operation with logic gates, it i only necessary to find ones which have the same Truth Table as that for binary addition. The circuit would require two inputs, A and B and two outputs to correspond to the Sum and Carry. This can, in fact, be achieved in several different ways; if you look back at the Truth Table for the EX-OR gate and the AND gate it is apparent that the Sum part is the same as the EX-OR truth table and the Carry part is the same as the AND gate. Actually, this is not quite a full solution, since no account has been taken of the fact that a Carry bit may have been produced by an earlier stage, and hence this is known as the half-adder.

Half-Adder Circuit

A digital half-adder circuit may be made up, on a bread-board, following the diagram given in Figure 9. Here it can be seen that the two gates which are required are the EX-OR and the AND gates. Possibly the most convenient method of making up this circuit is to use single gates from a 7486 and a 7408, and connect them up as shown. In this case the two bits to be added are applied to inputs A and B to give the Sum and Carry appear at the corresponding outputs. It is also possible, remember, to make up such gates as these from the common NAND gate. We have already seen how the EX-OR gate may be made up from four 2-input NAND gates, and so to complete the picture figure 10 shows how the AND gate may be fashioned. It is left as a further exercise for the reader to make up the half-adder circuit from NAND gates and confirm that it is logically identical to the first design.

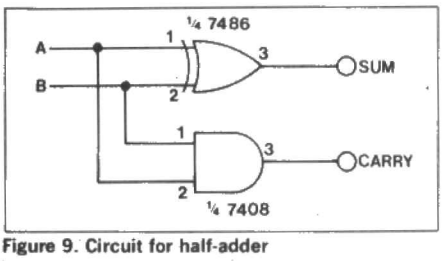


Figure 9. Circuit for half-adder

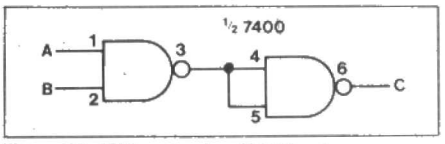


Figure 10. AND gate using NAND gates

Full-Adder Design

The half-adder is incomplete in that no provision is made for a 'carry-in' from a previous stage. In the case of the full-adder, not only is account taken of this, but also a provision is made for the possible generation of a 'carry-out' to subsequent stages. Again, the requirements of the full-adder may best be summarised in the form of a Truth Table; this will need to have three inputs, A,B and Carry In, with two outputs, Sum and Carry Out, as shown in Figure 11.

A	B	CARRY IN	SUM	CARRY OUT
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Figure 11. Truth table for binary full adder

The full-adder is, in essence, two half-adders connected together to take account of the extra bit carried in. The circuit for the full-adder is given in Figure 12. Again, although this is shown made up from discrete gates, it can also be done with NAND gates in the same manner as the half-adder.

If more than two bits are to be summed then the block can be repeated, with the carry out from one stage being connected to the carry in of the next stage. Finally, Figure 13 shows a couple of full-adders being used to add binary 11 and 11, giving 110; ie decimal 3+3=6.

Address Decoding

Still on the micro-processor scene, another important use of TTL combinational logic designs is in the area of address decoding. The essential problem here is to produce a signal in response to a unique pattern of bits on the micro-processor address bus. This pattern of bits is, of course, the address of the device which is being sought in order to send or receive data along the data bus of the system. Typically,

Continued on page 64

Logic Probe

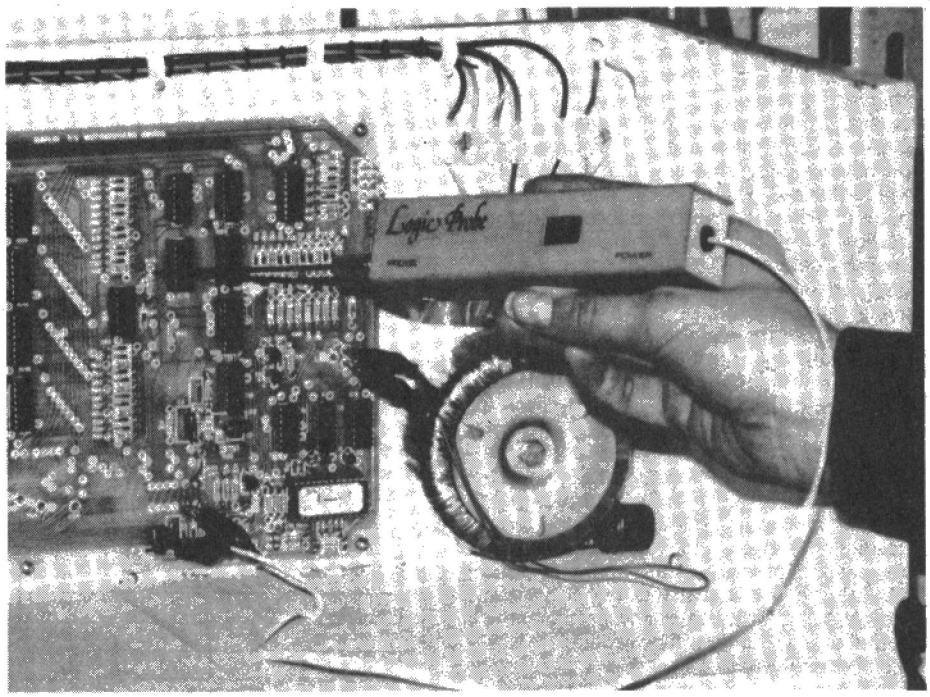
by Graeme Durant

- ★ **Detects pulses from around 1Hz**
- ★ **Instantly recognisable logic states**
- ★ **Low current consumption**
- ★ **Over volts protection**

Over the years, countless designs have appeared in the electronics press for logic probes; ranging from very simple High/Low indicators, to complex pulse stretching probes. The logic probe described here, has a number of features found only on the more complex probes, and as such, lies somewhere between these two extremes. Thus it is perfectly suited to day to day fault diagnosis.

As well as detecting High and Low logic states, open circuit (floating input) and pulsing inputs are displayed. Pulse trains from around 1Hz are detected as a pulsing input, the upper limit is above that attainable in most common C-MOS logic.

The main difference between this logic probe and all others is that the output is shown on a seven segment LED display, as a letter of the alphabet; Hi for High; L for Low; F for Floating; P for Pulsing. In this way, the logic state is instantly recognisable and totally unambiguous, unlike some commercial logic displays. The use of a special high efficiency display means that the total current consumption at a supply voltage of 15v is only 15mA - quite suited to battery operated circuits. In addition, the probe is protected against overvoltage inputs, and reversed supply.



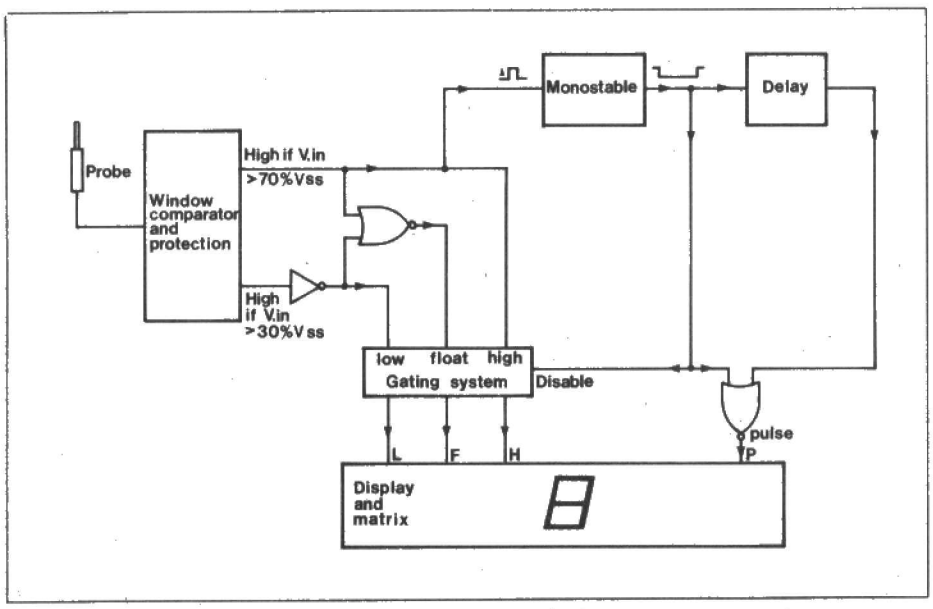


Figure 1. Block diagram.

Block Diagram

The input from the probe goes via a protection network to a window comparator, with switching levels of 70% Vss and 30% Vss; these are the standard CMOS limits. If the upper limit is exceeded, then the probe input is CMOS logic high. Thus, the upper output goes on to the display circuitry for HIGH indication.

If the probe input does not exceed the lower limit, then it is at CMOS logic low. The output of the lower comparator is inverted to give a high level at the display circuitry for LOW indication. If the probe input is between logic levels,

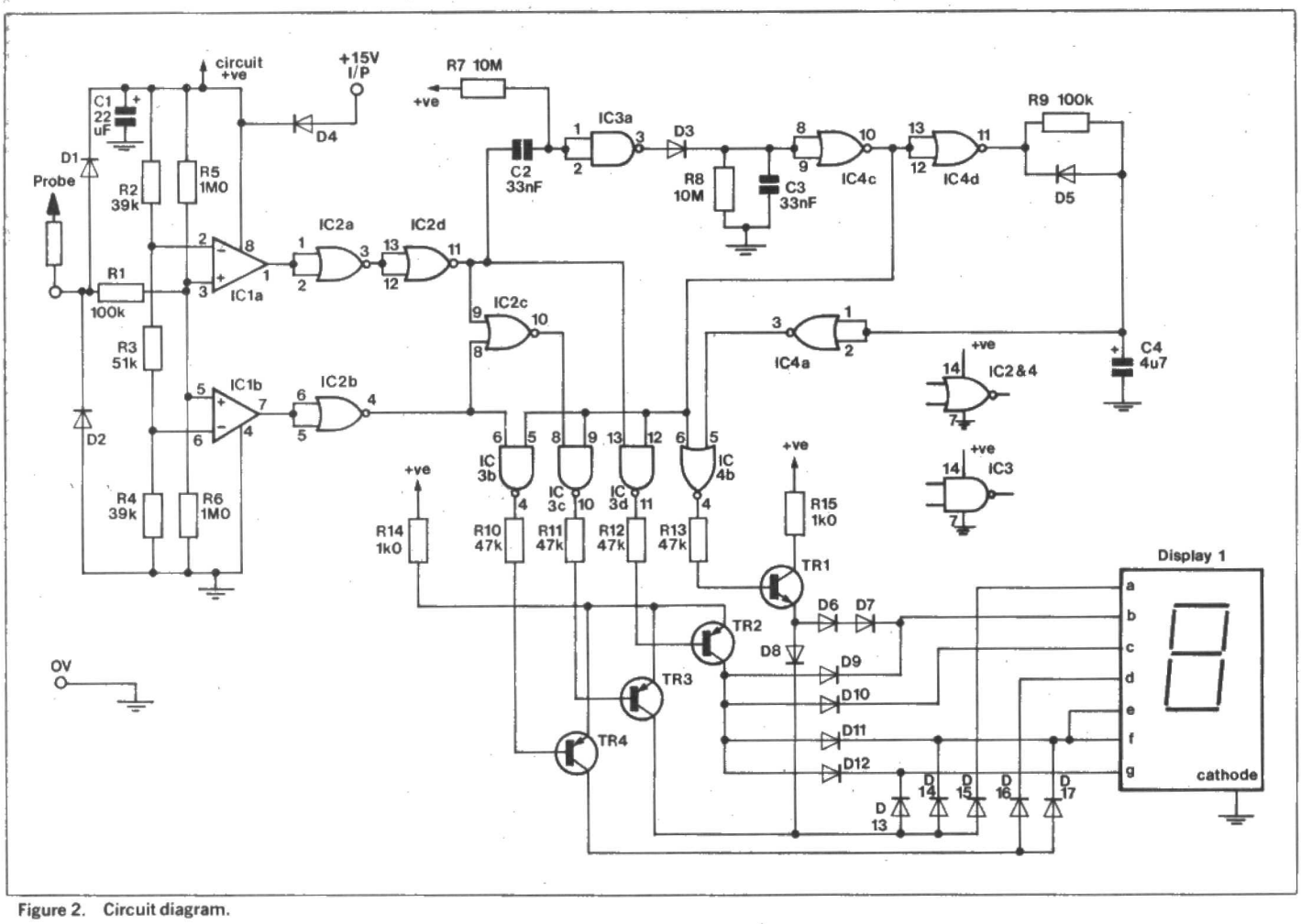
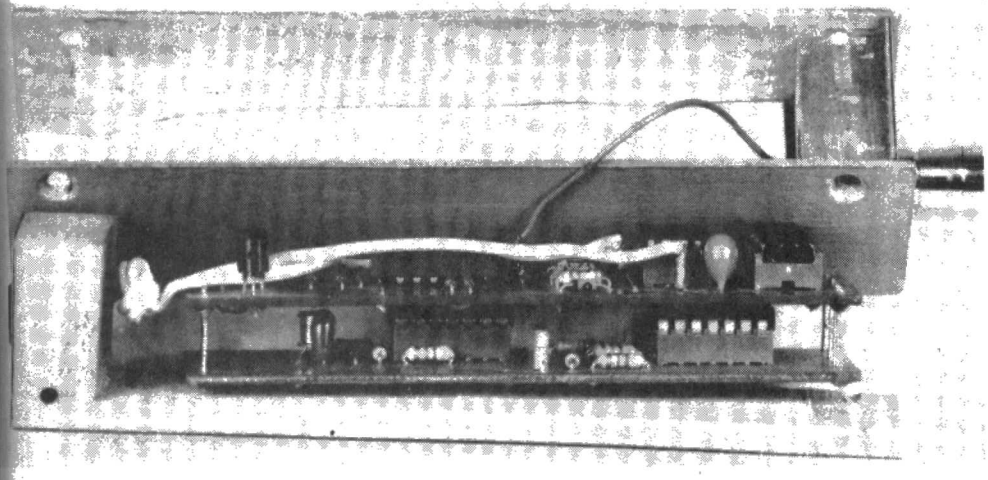


Figure 2. Circuit diagram.



then the upper comparator will be low and the lower comparator high. These two outputs are fed to a NOR gate, which gives a high level to the display circuitry on FLOAT.

The HIGH indication also drives a retriggerable monostable. will produce a continuous low output. If this monostable goes low, the display is disabled via a simple gating system. This is to prevent misleading displays, whilst the circuit decides whether the input is indeed pulsing, or whether a low to high transition has taken place (e.g. the probe has just touched a point at logic high). As soon as a low pulse appears at the monostable output, a delay, slightly

PARTS LIST FOR LOGIC PROBE

Resistors: All 0.4W 1% metal film unless specified

R1,9	100k	2 off	(M100K)
R2,4	39k	2 off	(M39K)
R3	51k		(M51K)
R5,6	1MO	2 off	(M1MO)
R7,8	10M	2 off	(B10M)
R10-13	47k	4 off	(M47K)
R14, 15	1k0	2 off	(M1KO)

Capacitors

C1	22uF 25V Tantalum		(WW73Q)
C2, 3	33nF polycarbonate	2 off	(WW35Q)
C4	4u7F 35V Tantalum		(WW65V)

Semiconductors

IC1	CA3240E		(WQ21X)
IC2, 4	4001BE	2 off	(QX01B)
IC3	4011BE		(QX05F)
TR1	BC107B		(QB31J)
TR2, 3,4	BC557	3 off	(QQ16S)
D1, 2	BAR28	2 off	(QQ13P)
D4	1N4001		(QL73Q)
D3, 5-17	1N 4148	14 off	(QL80B)
Disp.1	Low current disp.		(QY54J)

Miscellaneous

Printed circuit board (top)		(GB30H)
Printed circuit board (bottom)		(GB31J)

Additional parts if required

8pin DIL skt		(BL17T)
14pin DIL skt	3 off	(BL18U)
Screened phono plug		(HH01B)
Threaded phono skt		(YW06G)
Croc. clips		(HF25C)
Zip wire	1 metre	(XR39N)
Filter red		(FR34M)
Veropin 2141	1 pkt	(FL21X)

A complete kit of all parts is available. Order As LK13P (Logic Probe Kit). Price £9.95.

longer than the monostable period is initiated. At the end of this time period, if the output of the monostable is still low, i.e. the input is pulsing, the display shows PULSE. Otherwise, the HIGH/FLOAT/LOW display is enabled again.

The display consists of driver transistors, a diode matrix to produce the desired alphabetic displays, and a seven segment LED display.

Circuit Description

The probe input goes via R1 to a simple window comparator formed around IC1. R2, R3 and R4 determine the changeover voltage levels. The circuit input is protected from overvoltage by D1, D2 and R1; the input is biased at half supply by R5 and R6 so that if the input is open circuit, the display shows FLOAT. The upper window comparator output is buffered by IC2a and IC2d, and goes to the display switching transistor for HIGH indication, via IC3d, which allows the HIGH display to be disabled.

The low and float displays are similarly connected, using IC2b and IC3b for LOW, and IC2c and IC2c and IC3c for FLOAT.

A simple CMOS monostable wired around IC3a and IC4c, and having a period of around 0.5 seconds senses a pulsing input. Its output, which is normally high, disables the HIGH/FLOAT/LOW display, and starts a delay, formed around C4 and R9, which is a little over the monostable period. The output of the RC delay is inverted and fed to IC4b, which senses whether the input is still pulsing. If it is, Q1 is switched on, and PULSE is displayed. Otherwise Q2 to 4 are enabled. A diode matrix and seven segment common cathode display decode the signals, so as to give H, F, L and P displays.

'Construction'

Before soldering in any components, solder in wire links on both PCBs, there are eight in all. Fit in all the resistors and capacitors, taking care with polarity on C1 and C4. If you are using IC sockets these may be fitted along with the diodes — again be careful about polarity. Note also, that D4 is fitted vertically on the PCB. Fit the transistors, and finally, the ICs. It is a good idea to use veropins for all the cable to PCB connections, but it is not vital. This only leaves the display, which requires setting at the correct height to fit inside a suitable case.

The PCBs are mounted one on top of the other in the case, with connections between made by solid wire links - cropped component leads are ideal. Solder eleven lengths of wire, about 20mm long, to the underside end connections of the top board, passing the wire through the holes until level with the topside of the PCB. See Figure 5.

Slide on the lower board, until there is a gap of a millimetre or so between the top board and the tallest components

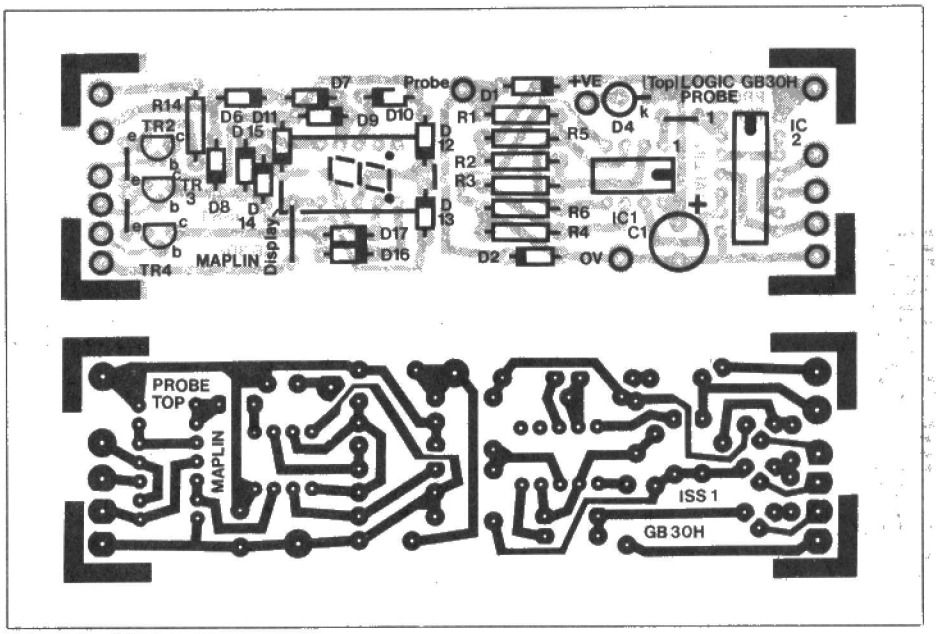


Figure 3. PCB layout.

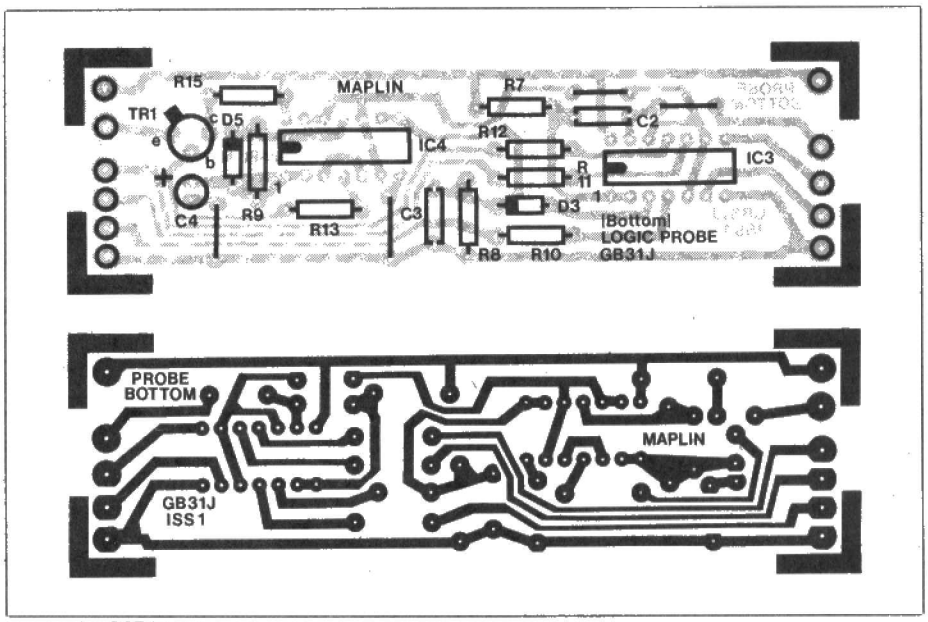


Figure 4. PCB layout.

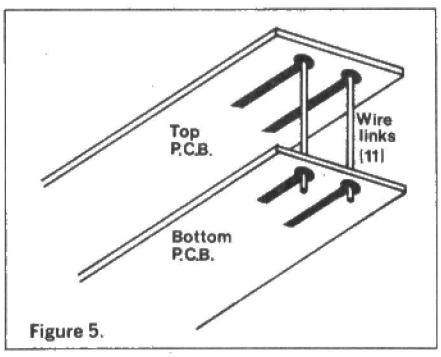


Figure 5.

on the bottom PCB. Solder the wires to the bottom board and crop as normal.

The circuit now may be fitted into the case, insulated from the case bottom by masking tape and held firmly in position by sticking a strip of thin foam rubber in the lid, with a cutout for the display. A small square of red display filter film may be stuck behind the cutout for the display for easier viewing.

The power cable, a piece of Zip wire terminated in crocodile clips must pass through the case via grommet. The probe, made from a sharpened steel rod or knitting needle, is soldered into a Phono plug, and connected to the circuit by a case mounted Phono socket. This provides a firm grip and allows easy storage of the probe when not in use.

Testing and Use

Power the circuit up with a typical CMOS supply voltage. After around half a second, the display should show a letter F. If not, disconnect quickly, and recheck the circuit. If all is well, touch the probe to positive - a letter H should be light after a brief delay. Tap the probe on and off positive a few times a second - a letter P should be displayed after a delay. Then, touch the probe to Ov - a letter L should light immediately. If all this happens, the probe is working perfectly.

The probe is designed for use with CMOS logic circuitry, and may be used to trace faults on any such logic. All that remains now is to find a suitable circuit to test!

MACHINE CODE PROGRAMMING WITH THE 6502

Part Two

Graham Dixey C.Eng., M.I.E.R.E.

Memory Addressing

Little progress can be made in writing machine-code programs without a reasonable degree of understanding of the addressing modes available. The better the understanding, the better the programs. In a program written by the user, all of the instructions and data will be entered into the RAM area of memory, and running the program will access these instructions and data sequentially. Questions then naturally arise. Whereabouts in the RAM should the program be located? What are the criteria that determine the choice of locations? Given that there are a variety of ways of loading and storing data, how does one decide which method to use? It is the intention of this article, the second of this series, to answer these questions by showing how some of the 6502 addressing modes work. So that it is possible to 'see the wood in spite of the trees', no attempt will be made at this stage to write anything very ambitious in the way of programs. That can come later. But the first 6502 mnemonics and their corresponding op-codes will be met so that addressing can be seen to be used in a meaningful sense.

The Paging Concept

Memory is organised in 'pages', each 256 bytes long. These are known as 'Page 0', 'Page 1', 'Page 2'... 'Page E', etc. The page number is obtained by writing the memory addresses in numbers of four HEX digits length and examining the two most significant digits.

Thus, Page 0 runs from 0000 to 00FF
Page 1 runs from 0100 to 01FF
Page 2 runs from 0200 to 02FF

Page E runs from 0E00 to 0EFF
etc.

This idea of pages is more important than might be thought. For one thing, it is possible to write a shorter (and hence faster) program on Page 0 than on others - because of a unique addressing mode that will be explained shortly. Secondly, crossing a page 'boundary' in certain operations incurs a loss of speed.

A pictorial method of illustrating memory is the 'memory map', an example of which is shown in Figure 1. This shows both

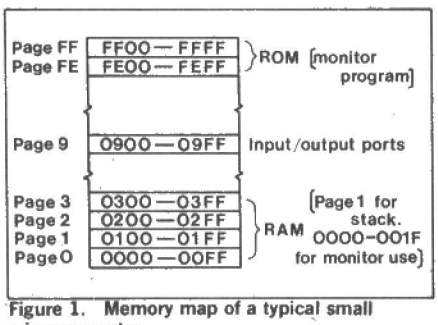


Figure 1. Memory map of a typical small microcomputer.

the pages referred to and also the way in which they are allocated. This memory map may be taken to represent a typical small development microcomputer with just 1K of RAM and 512 bytes of ROM. Whatever computer is concerned, it will be necessary to determine its memory map so as to know (a) which areas of RAM are available for user programs and (b) where the input/output ports are located. The 'stack' is standard on all 6502-based machines, being located on Page 1 - thus this page is not to be used for user programs, except in stack operations. One word of warning - the monitor program, which is stored in ROM and controls the computer operation, may well have a small part of one of the RAM pages (e.g. Page 0) reserved for its own use for what is known as a 'scratch-pad'. User programs should not be written here as strange things will happen!

Assembly Code and Machine Code - the first mnemonics

Assembly and machine codes are both termed 'low-level languages'. Assembly code consists of easily recognisable mnemonics and is the form in which the program is first written. When there is a good chance that the program will work, then it can be put into machine code; this consists of op-codes and data, whose meanings at a glance are much less obvious. It is as well to be disciplined in approching program writing right from the start, since a well laid out program is easier to de-bug than one in which the logical approach is missing. When writing the Assembly Code program space should be left alongside for the related machine-code program; then a direct correspondence between the two can always be seen.

Now for a few instructions and their Assembly Code mnemonics:

SED - Set the Decimal mode (for arithmetic operations)

LDA - Load the Accumulator (with the byte of data specified in some way by what follows next)

The bracketted words actually refer to the addressing mode to be used.

CLC - Clear the Carry (flag): sets the carry flag to zero

ADC - Add with Carry (adds the contents of the accumulator - plus the carry flag - to the data specified by what follows next) This operation was illustrated diagramatically in Part One of this series.

STA - Store the accumulator contents (at a location determined by what follows next)

These mnemonics, as listed, actually form a short program that adds together two numbers and stores the result. The only problem that needs them to be solved is how to address the memory, both to fetch the data, i.e. the numbers to be added, and to

MNEMONIC	OP CODE	OPERATION
BRK	0 0	Break
CLC	1 8	0 → C
CLD	D 8	0 → D
CLI	5 8	0 → I
CLV	B 8	0 → V
DEX	C A	X-1 → X
DEY	8 8	Y-1 → Y
INX	E 8	X+1 → X
INY	C 8	Y+1 → Y
NOP	E A	No operation
PHA	4 8	A → Stack
PHP	0 8	P → Stack
PLA	6 8	Stack → A
PLP	2 8	Stack → P
RTI	4 0	Return from interrupt
RTS	6 0	Return from sub-routine
SEC	3 8	1 → C
SED	F 8	1 → D
SEI	7 8	1 → I
TAX	A A	A → X
TAY	A 8	A → Y
TSX	B A	S → X
TXA	8 A	X → A
TXS	9 A	X → S
TYA	9 8	Y → A

Table 1. 6502 instructions using inherent addressing.

store the result of the addition. So now to some 6502 addressing modes.

Inherent Addressing (Implied)

There are two instructions in the above program that use this mode. They are SED and CLC. This is the simplest form of addressing since it is complete as it stands; there is no following data byte/s. This is a 'single-byte' instruction which is performing an operation which is totally self-contained within the MPU chip. The complete list of 6502 instructions that use this mode are given in Table 1.

Zero Page Addressing

This mode provides access to all memory locations on Page 0 i.e. the addresses in the range 000 - 00FF. These are 'two-byte' instructions; the first byte is the instruction itself e.g. LDA; the second byte is the Page 0 address where the data is located. Suppose as an example this address is 0030; using zero page addressing this is specified simply by the HEX number 30. It is a utility of 6502 programming that all Page 0 addresses can be identified by using the low byte of the address only; for all other pages of memory both bytes must in some way be specified. It is for this reason, as mentioned earlier, that programs on Page 0 run faster than those on other pages.

The op-code for LDA on Page 0 is A5 so that the program line in machine code for this operation is:

A5 30

It should now be appreciated that this represents an instruction to the MPU to load its accumulator with whatever number it finds at memory location 0030 - in a language which it can understand i.e. HEX machine code. Actually that is a half-truth since there also has to be a further translation from HEX into binary, but this is not a worry of the programmer; the machine sorts this out itself.

Immediate Addressing

This is also a 'two-byte' addressing mode but with the following important difference. The second byte is not an actual address for the data but is the 'data itself'. To distinguish it from zero page addressing the # (hash) is used in Assembly Code and, of course, the op-code for machine-code is different. This is illustrated by the following example:

Assembly Code	Machine Code	Comments
LDA MEM1	A5 30	Zero page mode (meaning Load Accumulator with data at address 0030)
LDA #30	A9 30	Immediate mode (meaning Load Accumulator with the number given i.e. 30)

Notice one point of protocol - in the Assembly Code for zero page the memory location is simply referred to as MEM1, whereas in the corresponding machine code the actual address is specified i.e. 30=0030. MEM1 is called a 'label' and is generally used in writing Assembly Code programs so as to preserve a general approach to program writing. It is later, when the program is encoded into machine code, that the actual memory location to be used can be assigned.

Absolute Addressing

Naturally it often happens that access is required to memory locations that are on another page other than Page 0. One way of achieving this is to use the 'three-byte' mode known as absolute addressing. The first byte is the appropriate op-code followed by the full two bytes of the address. Straightforward enough evidently but note that in machine-code the 'low' byte of the address comes 'first', thus; the op-code for LDA in this mode is AD so that, to load the accumulator from the Page 3 memory location 031A, the program line in machine-code would be - AD 1A 03. Obviously a point to remember.

The instructions that can use the Immediate, Zero Page or Absolute addressing modes are listed in Table 2. together with their op-codes.

	ASSEMBLY CODE				MACHINE CODE		
LABEL	MNEMONIC	DATA	COMMENTS	PC	OP CODE	DATA/ADDRESS	
					BYTE 1	BYTE 2	BYTE 3

Figure 2. Scheme for headed programming sheet.

	ASSEMBLY CODE				MACHINE CODE		
	LABEL	MNEMONIC	DATA	COMMENTS	PC	OP CODE	DATA/ADDRESS
						BYTE 1	BYTE 2 / BYTE 3
(a)		SED		Sets dec. mode	0020	F8	
		LDA	MEM1	MEM1 → A	21	A5	30
		CLC		0 → C	23	18	
		ADC	MEM2	MEM1+MEM2 → A	24	65	31
		STA	MEM3	A → MEM3	26	85	32
		MEM1=0030; MEM2=0031; MEM3=0032					
(b)		CLD		Clears dec. mode	0050	D8	
		LDA	MEM4	MEM4 → A	51	A5	60
		SEC		1 → C	53	38	
		SBC	#10	MEM4 −10 → A	54	E9	0A
		STA	MEM5	A → MEM5	56	8D	1F / 03
		MEM4=0060; MEM5=031F					
		N.B. → means "goes into"					

Figure 3. Two simple programs: (a) single-byte addition (b) subtraction.

MNEMONIC	OP CODE			OPERATION
	IMM.	ABS.	0 Page	
ADC	69	6D	65	A+M+C → A
AND	29	2D	25	A∧M → A
ASL		0E	06	C ← [ ] ← 0
BIT		2C	24	A∧M
CMP	C9	CD	C5	A−M
CPX	E0	EC	E4	X−M
CPY	C0	CC	C4	Y−M
DEC		CE	C6	M−1 → M
EOR	49	4D	45	A∨M → A
INC		EE	E6	M+1 → M
JMP		4C		Jump to:
JSR		20		Jump sub
LDA	A9	AD	A5	M → A
LDX	A2	AE	A6	M → X
LDY	A0	AC	A4	M → Y
LSR		4E	46	0 → [ ] → C
ORA	09	0D	05	A∨M → A
ROL		2E	26	[ ] ← C
ROR		6E	66	C → [ ] →
SBC	E9	ED	E5	A−M−C → A
STA		8D	85	A → M
STX		8E	86	X → M
STY		8C	84	Y → M

Table 2. 6502 instructions using immediate, zero page or absolute addressing.

Two Simple Machine Code Programs

The list of instructions for a simple 'single-byte' addition program has already been given. This program can now be encoded into machine-code in order to illustrate the way in which a written program may be laid out and to clarify, if needed, some of the instructions.

It will be necessary when writing the machine-code program to assign actual memory locations. As already explained, those addresses available will vary from one machine to another. However, rather than get round the problem by putting in a series of Xs whenever an address is needed, as it is sometimes done, the memory map of Figure 1. will be used. This approach is much more meaningful in terms of learning how to write programs, and it is only necessary for the individual programmer to remember that he may well have to assign different addresses for his own machine.

A headed programming sheet might look something like that shown in Figure 2. The column headed LABEL is only needed for programs containing 'branches' or 'jumps' but, for a general purpose programming sheet it should be included. PC stands for Program Counter, of course, and it is this register that holds all of the program memory locations, in turn, as the program runs.

Figure 3. shows two of the simplest programs possible - single-byte addition, and subtraction. These are included to illustrate the use of the programming sheet as well as the addressing modes that have been discussed so far.

The addition program starts by selecting the 'decimal' mode i.e. all data is handled as Binary Coded Decimal (BCD); the alternative mode is HEX. The accumulator is then loaded with the contents of the location labelled MEM1 (actual address 0030) and the carry flag is cleared prior to the addition. This step is necessary since the state of the carry flag is quite arbitrary at this instant and the 6502 instruction set has only the one addition instruction, which always includes the carry bit. Next the accumulator contents and the data at MEM2 (0031) are added together, the result being retained in the accumulator. This sum is then stored at MEM3 (0032). The whole program has been carried out on Page 0.

MNEMONIC	OP CODE	OPERATION
BCC	90	Branch on C=0
BCS	B0	" " C=1
BEQ	F0	" " Z=1
BMI	30	" " N=1
BNE	D0	" " Z=0
BPL	10	" " N=0
BVC	50	" " V=0
BVS	70	" " V=1

Table 3. 6502 instructions using relative addressing.

The subtraction program could have been written on very similar lines but has been used, instead, as an illustration of the Immediate and Absolute addressing modes.

The program starts by clearing the decimal mode i.e. HEX arithmetic is selected (a choice entirely at the user's whim). The accumulator is loaded with the contents of MEM4 (0060) and the carry flag is 'set'. This must always be done before a subtraction so that 'borrows' can be made as required. The number subtracted from the accumulator contents is the decimal number 10 (immediate mode), which has to be written in HEX for the machine-code program and then becomes OA. The result of this subtraction is retained in the accumulator, which is then stored on Page 3 (at 031F), which requires absolute addressing.

Unless the above is absolutely crystal clear it would be as well to study these two programs carefully alongside Tables 1 and 2 so tht the op-codes used in them can be related to the addressing modes used. A look at the PC column shows that only the address for the first byte on a program line is given; however, the other addresses have been allowed for, as study of the PC column should make clear. For example, in the addition program there are eight bytes corresponding to the eight memory locations 0020 - 0027 respectively. Notice also that the subtracting program is longer at nine bytes because of the absolute mode used for the store operation.

Perhaps it might be as well to make it clear now that these two apparently trivial programs are included principally to illustrate the points made so far and to establish a structured approach towards programming. Obviously one does not need a computer just to add or subtract two numbers, but one might do so as part of a much larger and, hence, more complex program. In fact, such operations may need to be repeated many times during the course of a program run. They would then be called as 'sub-routines' each time required. It is intended to familiarise the reader with the whole of the 6502 instruction set and to show how to write programs to perform useful, mainly control-centred functions.

Relative Addressing

This mode is used only with 'branch' instructions, i.e. where a departure is made from the current address to another part of memory, as the result of a decision. This offers alternative courses of action based on the current state of affairs. For example, taking inputs to the computer from transducers and testing their values may decide the value of the output to some control element, perhaps a relay, lamp, motor, heater, etc. Flowcharts show clearly the action of branches. For example, Figure 4(a) shows the idea of testing an input and taking the appropriate action for a computer-controlled furnace, while Figure 4(b) shows the computer making this same type of decision based on the accumulator status. Table 3 lists all of the 6502 instructions that use relative addressing.

Obviously a change in program direction can be either forward or backward, i.e. a branch can be 'positive' or 'negative'. In relative addressing the 'length' of the branch is added to or subtracted from the current contents of the program counter, thus causing the program to branch suddenly from one area of memory to another. The length of the branch is simply the number of steps that must be made through memory to the required new location.

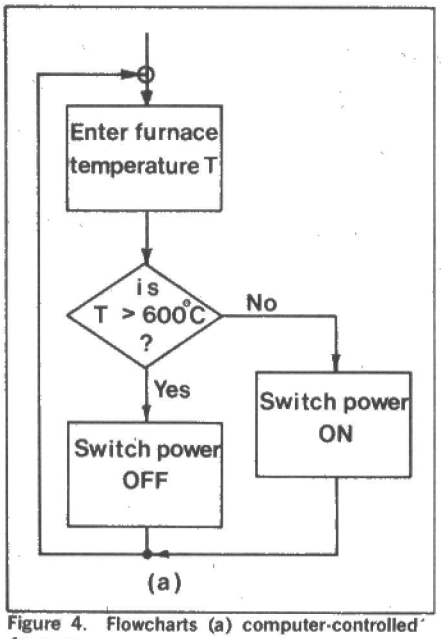
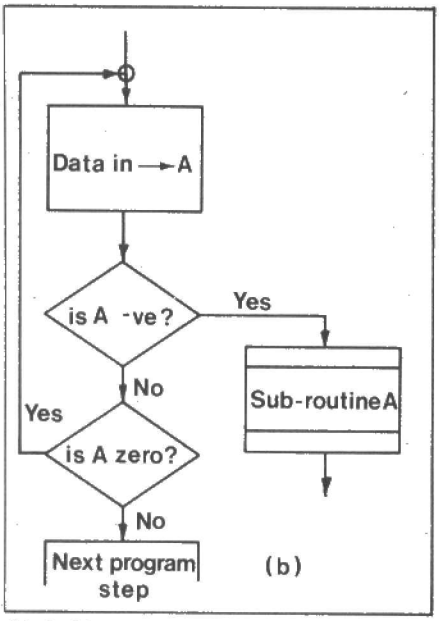


Figure 4. Flowcharts (a) computer-controlled furnace.



(b) decision making based on accumulator status.

Suppose that a positive branch must be made when the accumulator contents are negative and a negative branch is to be made elsewhere if these contents are instead zero, perhaps as the result of a subtraction that has just been performed. Otherwise, if the accumulator contents are positive the program doesn't branch at all but just proceeds to the next step in the program. The program segment might look like this:

```
LOAD  LDA   MEM1     0020  A5 E2
      SEC            22    38
      SBC   #20      23    E9 14
      BNE   OUT      25    D0 OA
      BEQ   LOAD     27    FO F7
              |
              |
              |
              |
OUT   STA   PORT B   003B  8D 00 09
```

The data for the BNE and BEQ instructions are the branch lengths, which are OA and F7 respectively, computed as follows.

(i) Positive branch: BNE to OUT; the memory location for the latter is seen to be 003B. When the program branches to this location it then finds the instruction to store the accumulator contents at the output port B. In this way the decision and action is taken to output data from the computer to some peripheral device. The question now is 'from where does the branch start?' The answer is that a branch always starts from the address immediately following the one at which the branch length is to be found - in this case 0027 (the branch length being at 0026). The reason for this is quite simple. The program counter is stepping sequentially through the program instruction and data bytes, each byte being sent in turn to the 6502's instruction register where it is decoded. While this decoding is taking place, the program counter automatically increments to the next address in the sequence, so it is one step ahead when the branch length is in the instruction register. This instruction register, which has not been mentioned before, is for the decoding mentioned only and is not accessible to the programmer.

The branch length is therefore the number of steps between 0027 and 003B which is 10 in decimal or 0A in HEX. Count them!

(ii) Negative branch: BEQ to LOAD; this time it is necessary to go backwards to 0020. The branch starts at 0029 so, therefore, the branch length is -9 (the - sign indicates a negative branch) and this has to be written as a 'signed HEX number' - not as bad as it sounds.

Method 1.

(i) Write 9 in binary (8 bits) = 00001001
(ii) Complement it = 11110110
(iii) Add '1' to it = 11110111
(iv) Write this as two HEX digits = F7

Method 2.

Note the following sequence of HEX numbers:

F7	=	-9	
|		|	
|		|	
|		|	
FD	=	-3	Negative numbers
FE	=	-2	
FF	=	-1	
00	=	zero	
01	=	+1	
02	=	+2	Positive numbers
03	=	+3	

Imagine this as a continuous sequence around the surface of a cylinder. Where will the join be between positive and negative numbers? The answer is:

80 = -128 (highest negative number)
7F = +127 (highest positive number)

This is easy enough to grasp especially if the analogy is taken of a mechanical counter, such as the odometer in a car. If it was set at all zeros i.e. 0000, what would it read if it was turned back one notch, then two, etc? Easy enough of course - 9999,9998 and so on. So it is with HEX that going backwards (i.e. negatively) from zero gives the highest HEX digits first, then reducing by one at each step - FF, FE, etc.

A final point worth making now. Using relative addressing, the maximum distance that one can branch out through memory is 127 steps forward or 128 steps backward - or is it? There must be a way of branching as far as one likes, and this, plus more complex addressing modes will be dealt with in the next article. Also, since quite a bit of useful theory has now been covered in the first two articles, the time has come to start developing more useful and ambitious programs.

Dragon 32/RS232 Modem Interface

★ RS232 Data Link ★ Programmable word format
★ Will connect Dragon to the Maplin Modem or other compatible system
★ Module plugs into ROM expansion socket

by Dave Goodman

The first in a series of projects for the Dragon 32 computer is our Serial Communications Interface Adaptor, or SCIA. Although primarily designed for use with the Maplin Modem, the SCIA could connect to any serial RS232 compatible system where data exchange is required. It makes possible full communication between the Dragon and other computers, and many commercial information services, such as the Maplin Cashtel system.

Construction

Through pins are used to connect tracks on both sides of the PCB. Fit these first, and solder them on both sides of the board. Resistors and diodes are fitted next, bending each lead before insertion. On the legend a white bar shows the position for aligning the cathode of each diode, which in turn is recognised by a black band printed on the body. Fit RV1, and all the capacitors. C4, 5, and 6 are polarised, with the negative end marked on the body, while C7 is marked with a positive sign. Make

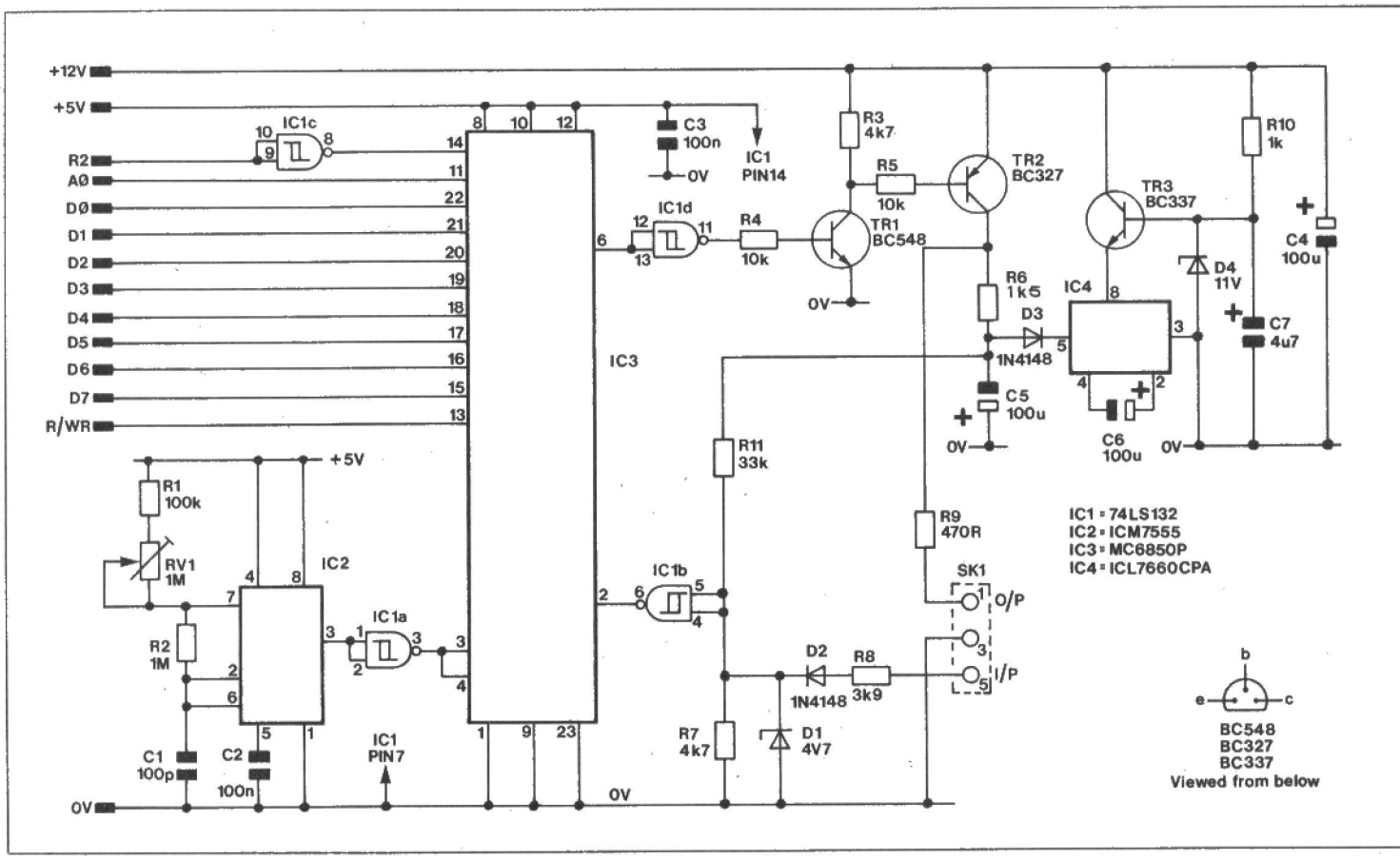
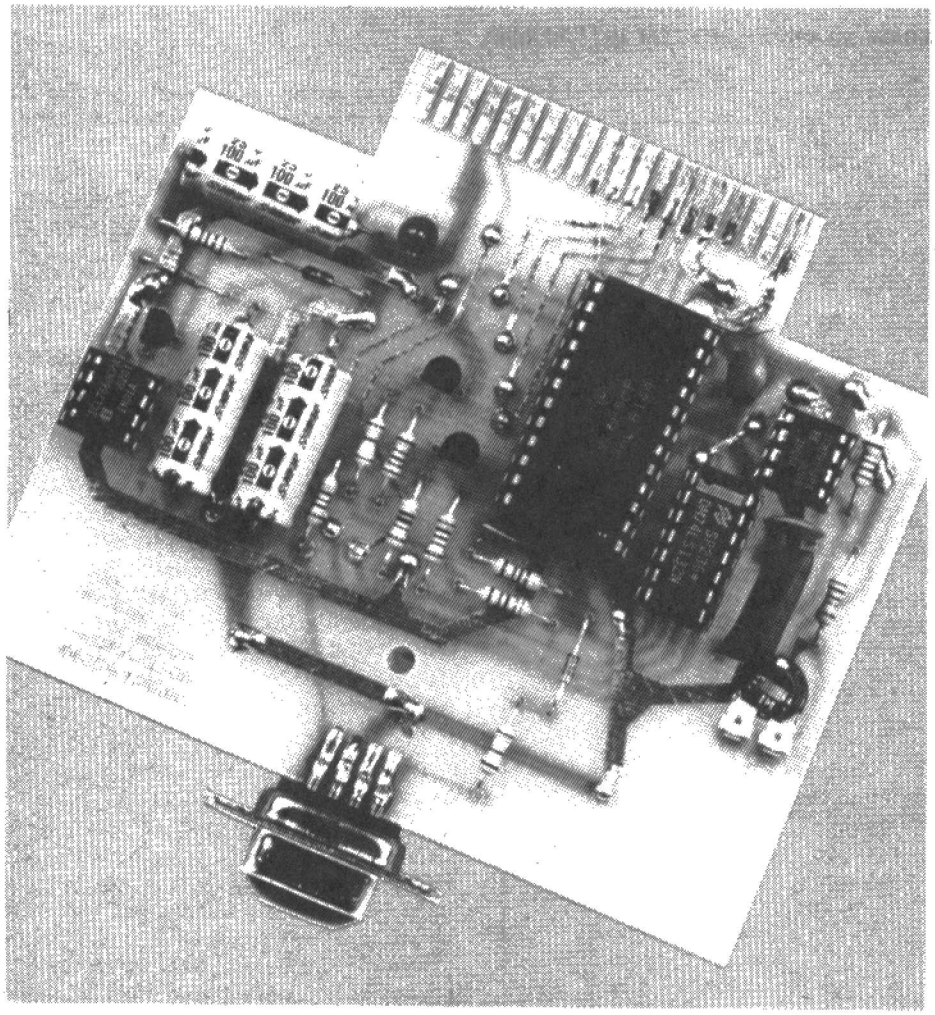


Figure 1. Circuit Diagram



sure they are fitted the correct way round!

Transistors TR1 to TR3 and all four IC sockets should be mounted as shown on the legend. Carefully solder each component in place, remove excess leads, and clean the track. Finally fit and solder SKT1 in place, then insert IC4 only. You should inspect your work before testing, rechecking all components and solder joints for errors.

Circuitry and Testing

Characters are transmitted or received at a particular speed, or Baud rate. The standard telecommunications speed of 300 Baud is used for the SCIA, and, although not critical, RV1 should be set with the centre of its wiper pointing to the arrow on the PCB legend. Insert the module (component side upwards) into the ROM expansion socket on the right hand side of the computer. Switch on the Dragon and wait for the usual display to appear. If vertical lining appears, or nothing at all happens, then switch off immediately and remove the module for inspection.

Using the positive end of C5 as the OV reference point, place a voltmeter between OV and IC4 pin 8, and check

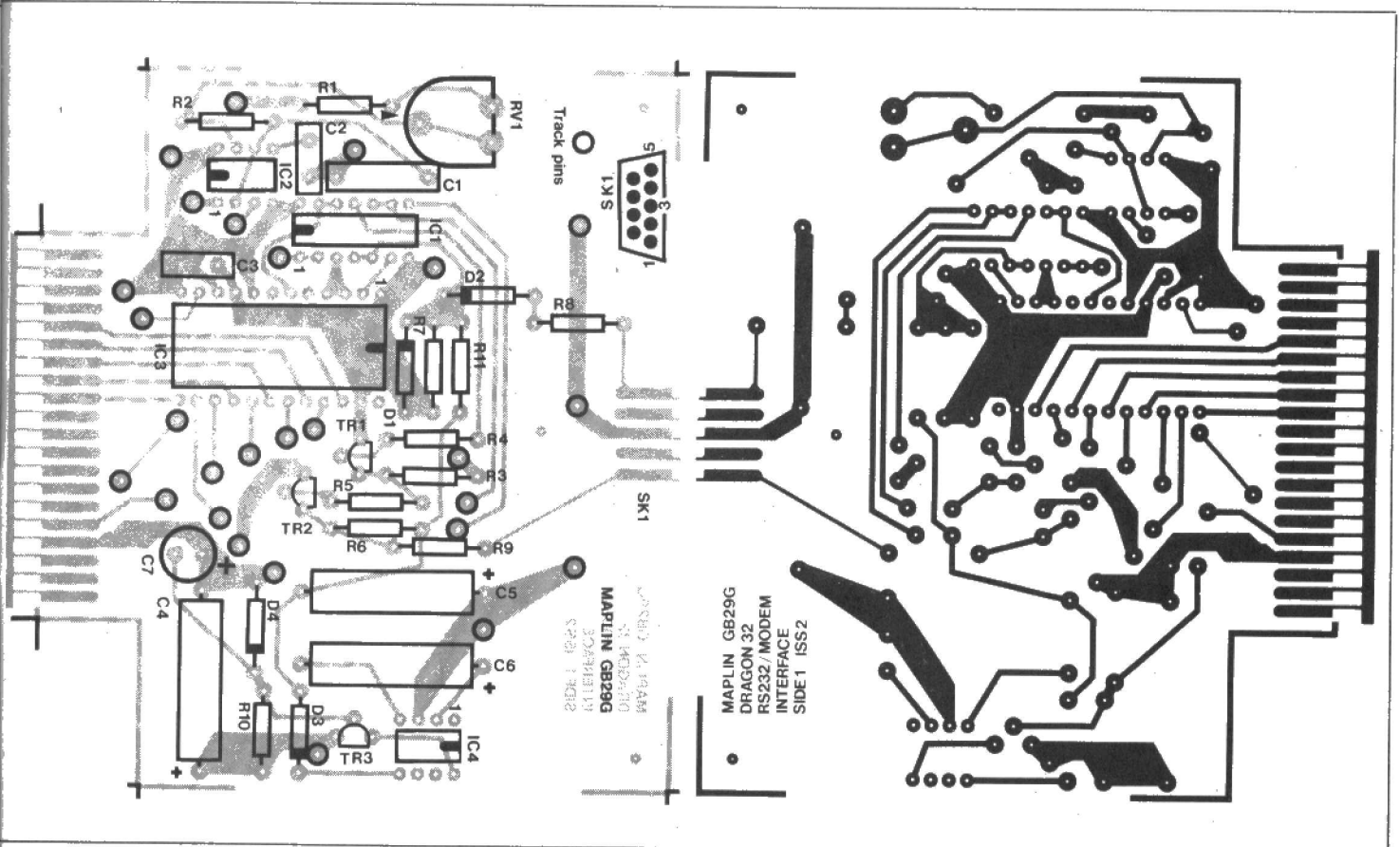


Figure 2. PCB legend and artwork

for approx. +10.3V. Now check for approx. -9.8V between OV and pin 5 of SKT1. Remove the module, insert the remaining ICs, and re-fit the module into the Dragon.

IC2 is a CMOS 555 timer, and is used for the clock oscillator. IC3 divides the clock signal to determine the Baud speed for character transfer. With a 4.8kHz clock and a programmed divide by 16 code, the Baud rate is 300. Three divide ratios of 1, 16 and 64 are available.

IC4 is a voltage inverter, producing -10V across C5 for a +10V input from TR3. This negative voltage is necessary to produce RS232 compatible levels for signal transmission. Serially coded signals are converted from pin 6 of IC3, IC1, TR1 and TR2 to RS232 +12V, -10V levels at SKT1, pin 5. Input signals on SKT1, pin 1 are chopped and potentially divided by R8, D2 and R7 to a level suitable for TTL use.

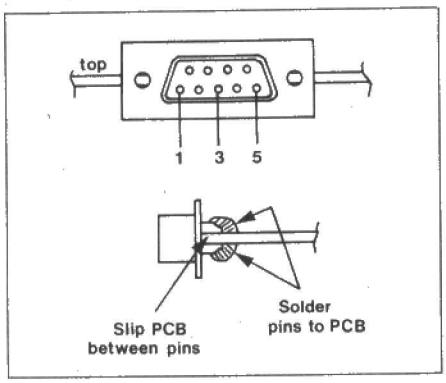


Figure 3. Plug and socket external connections

Incoming serially coded signals are decoded by IC3 into eight bit parallel data bus codes. By reading IC3, information is obtained from an internal status register. If correct conditions appear then data is transferred to the computer for processing, etc. Of course, the IC must be synchronised to the incoming data for such conditions as the number of STOP/START bits, a PARITY bit, ODD or EVEN, and the total number of bits expected. All this information is contained in Program 2 and Table 1.

Two addresses are used as ports: PORT A address is 49152, PORT B address is 49153. Port A may be read for status checks, or written to for setting internal control conditions. Port B is read for received character data, or written to for transmitting data. By using PEEK and POKE commands, an R2 pulse on pin 14 of IC3 will enable the system, otherwise data would appear permanently on the data bus — with interesting results!

```
10 CLS
12 PRINT@40,"'TEST PROGRAM'
14 PRINT@96,"CONNECT BOTH RS.232 (IP/OP)PINS TOGETHER,ON THE MODULE."
16 PRINT"THEN TYPE CHARACTERS DIRECT FROMTHE KEYBOARD!"
18 PRINT@234,"**********"
20 A=49152:B=49153
22 POKEA,3:POKEA,21
24 T$=INKEY$:IFT$=""THEN24
26 POKEB,ASC(T$)
28 IFPEEK(A)<3THEN28
30 PRINTCHR$(PEEK(B));
32 GOTO24
```

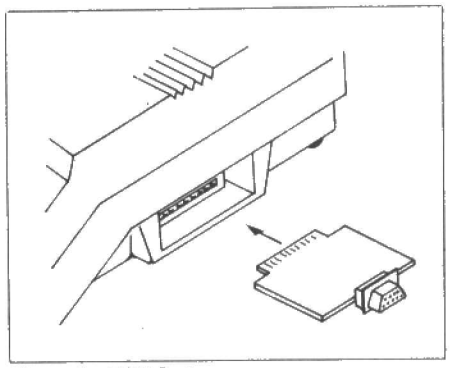


Figure 4. ROM Port

```
10 REM DRAGON MODEM PROGRAM
11 CLS
12 PRINT@41,"***MAPLIN***"
13 PRINT@73,"MODEM PROGRAM"
14 PRINT@128,"INSTRUCTIONS FOR USE:-"
15 PRINT@192,"1.CONNECT MODULE TO MODEM."
16 PRINT@256,"2.PROGRAM WORD FORMAT."
17 PRINT@320,"3.ESTABLISH COMMUNICATIONS LINK."
18 GOSUB200
19 PRINT@34,"THE MODULE IS PROGRAMMED BY"
20 PRINT@66,"ENTERING A'WORD-FORMAT'CODE"
21 PRINT@160,"THERE ARE 8 CODE OPTIONS LISTED"
22 PRINT"ON THE FOLLOWING PAGE."
23 PRINT@256,"SELECT THE REQUIRED WORD-FORMAT
   TO BE USED,";
24 PRINT"THEN ENTER THE CODE"
25 PRINT"USING KEYS 1 TO 8:-"
26 GOSUB200
27 PRINT@6,"'WORD-FORMAT'TABLE."
28 PRINT
29 A$(1)="(7BITS)EVEN PARITY+2STOP BITS"
30 A$(2)="(7BITS)ODD PARITY+2STOP BITS."
31 A$(3)="(7BITS)EVEN PARITY+1STOP BIT."
32 A$(4)="(7BITS)ODD PARITY+1STOP BIT."
33 A$(5)="(8BITS)NO PARITY+2STOP BITS."
34 A$(6)="(8BITS)NO PARITY+1STOP BIT."
35 A$(7)="(8BITS)EVEN PARITY+1STOP BIT."
36 A$(8)="(8BITS)ODD PARITY+1STOP BIT."
37 FOR I=1TO8:PRINTCHR$(I+48);
38 PRINT".";A$(I):NEXTI
39 PRINT@359,"PRESS KEY 1TO8!"
40 GOSUB201
41 IF K$<"1"OR K$>"8"THEN27
42 C=VAL(K$)
43 PRINT@103,"CODE SELECTED=";C
44 PRINT@162,A$(C)
45 PRINT@354,"DO YOU WISH TO CHANGE CODES?"
46 PRINT:PRINT@426,"(TYPE Y/N)"
47 GOSUB201
48 IF K$="Y"THEN27
49 IFK$<>"N"THEN43
50 PRINT@9,"PROGRAM DATA:-"
51 PRINT@64,"-";A$(C):PRINT
52 PRINT"- SPEED @ 300 BAUDS!"
53 PRINT@192,"TO START THE PROGRAM, PRESS ANY"
54 PRINT"KEY.THE SCREEN WILL CLEAR UNTIL"
55 PRINT"DATA IS RECEIVED!"
56 PRINT@320,"DATA TRANSMISSION IS DIRECT FROM"
57 PRINT@352,"THE KEYBOARD."
58 GOSUB201
59 FORI=1TOC:READ C
60 NEXT I
61 DATA1,5,9,13,17,21,25,29
62 A=49152:B=49153
100 POKE A,3:POKE A,C
110 T$=INKEY$
120 IFT$<>"" THEN GOTO 170
130 X=PEEK(A):IFX=2 THEN110
140 IF X=19 OR X=126 THEN100
150 PRINTCHR$(PEEK(B));
160 GOTO110
170 POKE B,ASC(T$)
180 GOTO110
200 PRINT@450,"(PRESS ANY KEY TO CONTINUE!)"
201 K$=INKEY$
202 IF K$=""THEN201
203 CLS:RETURN
```

Type in Program 1 and connect pins 1 and 5 on SKT1 together on the module. The idea is to transmit a character into the receive register and print it on the TV display, thus testing the module.

Line 22 first resets the status register and initialises both the receiver and transmitter using data code three (DØ and D1 = Logic 1), and second, a clock divide ratio of 16 is selected with code 1 (DØ = Logic 1) added to a word format code of 20 (D2 and D4 = Logic 1) or 21.

The keyboard is scanned to see if a key is being pressed, and, if so, an ASCII code value for the key is POKEd into Port B and transmitted, along with all bit information. Port A is scanned to see if correct data has been received, by looking for DØ = Logic 1. D1 will normally be at Logic 1 when the transmit data register is empty, so data code three (DØ and D1 = 1) is required to step the program forward, whereupon Port B is read and data printed on the display.

Run the program and press any key. The character will be printed, showing all is well.

Initial program requirements are for the setting of code 3 (POKE A,3) followed by divide code plus word format code (POKE A + total) 0 to 34.

Generally, code 21 can be used, which breaks down as divide clock by 16 and select word format of 8 bits (no parity) and 1 stop bit. This should suit most user requirements.

The MC6850 has many other control and status conditions associated with it, and a complete article could be written on this IC alone. However, informative data sheets are available from Maplin for those wishing to pursue the subject further. Program 2 gives information for those using the SCIA module and sets up the programming data to your requirements. ASCII coded data may be transmitted or received over a suitable link and printed to the display. If there is no 'echo-back' facility on the equipment connected to the module, then the characters transmitted from the Dragon will not be returned and printed. This facility exists for data clarification, so that you know exactly what you are sending out. Save all programs on tape for future use, and don't forget to dial 'CASHTEL' when ready to use the working module.

Table 1a Register Contents (Ports A and B)

Data Bus	Port B (Rx)	Port B(Tx)	Port A (write)	Port A (read)
DØ			Clock divide	Rx register full
D1	Receive	Transmit	Clock divide	Tx register empty
D2	Codes 0-127	Codes 0-127	Word Format	(Carrier Detect)
D3	ASCII	ASCII	Word Format	(Clear to Send)
D4	ASCII	ASCII	Word Format	Framing Error
D5	ASCII	ASCII	(Tx Control)	Rx Overrun
D6	ASCII	ASCII	(Tx Control)	Parity Error
D7	ASCII	ASCII	(Rx Int Enable)	(Int Request)

Table 1b (Control Register — Port A) Reset/Divide

Function	Data Bus DØ	D1	D2	D3	D4	D5	D6	D7	Code
Reset	1	1	0	0	0	0	0	0	3
Divide by 64	0	1	0	0	0	0	0	0	2
Divide by 16	1	0	0	0	0	0	0	0	1
Divide by 1	0	0	0	0	0	0	0	0	0

Table 1c. (Control Register — Port A) Word Format

Word Format	D2	D3	D4	D5	D6	D7	Code
7 bits. Even par. + 2 stop bits	0	0	0	0	0	0	0
7 bits. Odd par. + 2 stop bits	1	0	0	0	0	0	4
7 bits. Even par + 1 stop bit	0	1	0	0	0	0	8
7 bits. Odd par. + 1 stop bit	1	1	0	0	0	0	12
8 bits + 2 stop bits	0	0	1	0	0	0	16
8 bits + 1 stop bit	1	0	1	0	0	0	20
8 bits. Even par. + 1 stop bit	0	1	1	0	0	0	24
8 bits. Odd par. + 1 stop bit	1	1	1	0	0	0	28

DØ and D1 — see table 1b.

PARTS LIST FOR DRAGON 32 RS232/MODEM INTERFACE

Resistors — All 0.4W 1% Metal Film

R1	100k		M100k
R2	1M		M1M
R3,7	4k7	2 off	M4K7
R4,5	10k	2 off	M10K
R6	1k5		M1K5
R8	3k9		M3K9
R9	470R		M470R
R10	1k		M1K
R11	33k		M33K
RV1	1M Hor sub-min Preset		WR64U

Capacitors

C1	100pF Silver Mica		WX13P
C2,3	100nF Minidisc	2 off	YR75S
C4,5,6	100uF 25V Axial Electrolytic	3 off	FB49D
C7	4u7F 35V Tantalum		WW65V

Semiconductors

D1	BZY88C4V7		QH06G
D2,3	1N4148	2 off	QL80B
D4	BZY88C11V		QH15R
TR1	BC548		QB73Q
TR2	BC327		QB66W
TR3	BC337		QB68Y
IC1	74LS132		YF51F
IC2	ICM7555		YH63T
IC3	MC6850P		WQ48C
IC4	ICL7660CPA		YY75S

Miscellaneous

SK1	D-Range 9-Way Skt		RK61R
	8 Pin DIL Skt	2 off	BL17T
	14 Pin DIL Skt		BL18U
	24 Pin DIL Skt		BL20W
	P.C.B		GB29G
	Track Pin	1 Pkt	FL82D

A complete kit of all parts is available for this project.
Order As LK12N (Dragon/RS232 Interface kit). Price £13.75

USING THE COMMODORE 64

by Nigel Fawcett

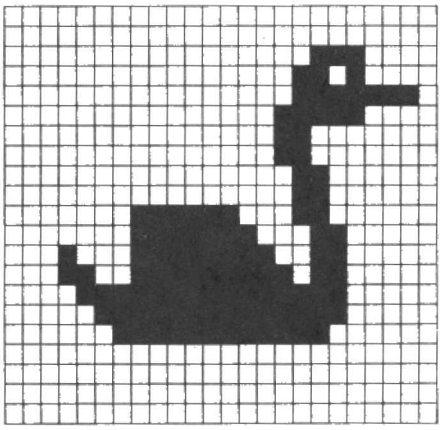
During the course of this and subsequent issues of Electronics I shall be including articles which should be of considerable use to the CBM 64 owner. These articles will cover many of the subjects which are not fully explained, or are merely hinted at in the manual which accompanies the 64. In many instances the 'Programmers Reference Guide' is mentioned and this publication is now available from Maplin, order code WK62S, price £13.25.

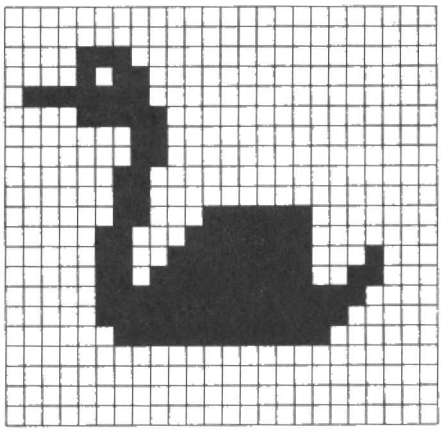
In this issue I shall demonstrate the use of the moveable object blocks or sprites as they have become known.

At the heart of the 64's graphics system lies the video interface chip (6567). This IC is responsible for managing the 40 column by 25 line text display, the 320 by 200 dot high resolution graphics display and the sprites (MOBS). In addition to these functions the 6567 also handles the character sets, split screen, colour modes, scrolling and a host of other graphics related jobs.

When the 64 user wants to write his own games, or even master the theory behind the commercially available arcade type games, it is natural that an understanding of mobs should be attained. The basic concept is that one should be able to define a shape, reasonably recognisable and proportioned for the application, and then be able to place it anywhere on the screen (this also includes those parts of the screen which lie above, below, left or right of the screen edges and which are therefore technically out of sight). In addition they should be able to move smoothly in any direction desired. Witht he 6567 all this is possible. First, graph paper should be used to design the bit pattern for the sprite. Each sprite is mapped on a grid which is 24 bits wide by 21 bits deep. Every bit which is 'on' will be displayed on the screen in the colour chosen for that sprite. In memory the data for the sprite patterns is arranged in 63 consecutive bytes

Continued on page 59





```
100 PRINT CHR$(147)
1000 FOR I=14336 TO 14463
1010 READ A : POKE I,A : NEXT I
1020 VC=53248
1030 POKE 2046,224
1040 POKE VC+21,64
1050 POKE VC+39,64
1060 VC+12,0 : POKE VC+13,100
1070 POKE VC+16,64
1080 FOR I=15360 TO 15400
1090 READ MC : POKE I,MC : NEXT I
1100 SYS 15360 : FOR I=0 TO 31
1110 NEXT I : GOTO 1100
3000 DATA 0,0,0,0,0,0,0,0,112,0,0,208
3010 DATA 0,0,254,0,1,240,0,1,128,0,1
3020 DATA 128,0,0,192,0,0,192,1,248,192
3030 DATA 1,252,96,17,254,96,25,255,96
3040 DATA 15,255,224,7,255,224,3,255
3050 DATA 192,0,0,0,0,0,0,0,0,0,0,0,0,0
3060 DATA 0,0,0,0,0,0,14,0,0,11,0,0,127
3070 DATA 0,0,15,128,0,1,128,0,1,128,0
3080 DATA 3,0,0,3,0,0,3,31,128,6,63,128
3090 DATA 6,127,136,6,255,152,7,255,240
3100 DATA 7,255,224,3,255,192,0,0,0,0,0
3110 DATA 0,0,0,0,0,0,0,0
3500 DATA 173,254,7,201,224,208,11,173
3510 DATA 12,208,201,36,240,15,238,12
3520 DATA 208,96,173,12,208,201,0,240.
3530 DATA 10,206,12,208,96,169,225,141
3540 DATA 254,7,96,169,224,141,254,7,96
```

MODEM NEWS

USER VIEWS

The Maplin Modem, and the CAShTel and Maptel services have been much more successful than anyone anticipated. Especially useful to us have been the user comments, a selection of which have been printed below. We are always interested in user comments and suggestions on what you would like to see on the system, e.g. User Group pages, bulletin board services. User groups (any machine) are welcome to get in touch with us, with the information they would like displayed, and we will see what we can do.

1. Terminating the isolating transformer with 600 ohms (across D1) enables correct setting of RV3. System now seems to have high immunity from noise. Stewart Hoare.
We agree that 600 ohms should give correct results, but, under practical conditions, the line rarely exhibits a 600 ohm impedance, and therefore the best way of setting up is to make a call to a friend and get them to leave their phone off the hook whilst you adjust RV3 for minimum crosstalk.
2. I have found it very difficult to get onto your system A. Perhaps it would be worth adding a few more ports? Roger Lee.
It is not extra ports that we need, but extra lines. More will be added in the future, according to demand.
3. If you sent Control N at the start of logon, please don't - it means reverse video to me. Andy Michael.
We don't.
4. How do I get rid of the double echo? Ian Atkins.
Either you are running in half duplex instead of full duplex, or there is something in your program which is giving a double echo.
5. It would be nice to have column width selectable. S.R.Vann.
It would, we agree, but there are just too many options, and this makes it impracticable at present.
6. Why don't you use both upper and lower case? Roderick McLeod.
We do receive both upper and lower case, but we cannot transmit using lower case because of the problems this causes for some micros (notably the Dragon), which will not accept it.
7. A problem occurs with your system not always echoing back my characters. This is only confined to your system and not the others I use. Anon.
Our system should always echo back, and we have not had any other complaints. Any comments from anyone else?
8. When will bulletins become available? J.P. Cowell.
During August.
9. I would like to see a good modem program for the BBC that loads to cassette. R.H. Gregory.
There is one published in this issue.
10. I am using a Transdata 300 printer terminal and I find that there are two characters missing at the beginning of each line, due (I think) to the slow return of the carriage in between lines. Is there any way of delaying the output from your computer? Michael King-Beer.
Please transmit 3-5 DEL characters after 'CR' 'LF' to allow elderly mechanical terminals time. Anon.
There is nothing we can do at present, but we are looking into this one. Please bear with us.
11. At 300 Baud Maptel is fairly slow. Are there any plans for other speeds, e.g. 1200/75 and 600? Mike Harvey.
We are looking into the possibility at the moment, and hope to have something fairly soon.
12. Please let us have a CBM 64 group page. P.A.Friend.
Would you consider making a page available for Maplin Modem users? Dr N.Robinson.
Your wish is our command.
13. Why is there no delete feature on input of messages? Mike Hobbs.
Delete vary too much between different computers. However, we are rethinking this one.
14. I would appreciate it if you would enrol me as a user of your system. I have a Barclaycard number, please advise me of the procedure. Also, I would like to know if the system will eventually be available after 17.30 hours, and if so until what time? P.A.Friend.
You do not need to be 'enrolled' into our system. The only requirement is that you have a customer number, which you can obtain by writing to us, enclosing your name and address, and details will be mailed to you. Alternatively, if you have already placed an order with us, you will have a customer number, and can use that.
The Maptel/Cashtel system is in the process of continuous expansion (as some of you may have noticed!), and we are experimenting with a non-interactive order system outside normal working hours at present. We hope this will provide a viable alternative, but we will consider making the full service available should the demand prove sufficient to justify it.

MODEM BOX

At last! The Maplin Modem has a box available. Custom built for us, the front panel is silk screened with a legend in white on black, and the rest of the box an attractive dark blue. The whole case comes in just two pieces, and will make your modem look completely professional.
All this for the incredibly low price of only £9.95. Order As YK62S (Modem Box).

```
 5 REM  BBC VDU PROGRAM  R.J.B.K.83
 10  CLS
 20 * FX 7,3
 30 * FX 8,3
 40 * FX 2,2
 50 A = INKEY(1): IF A = -1 THEN 100
 60 * FX 3,7
 70 VDU A
 80 * FX 3,0
 90 GOTO 40
100 * FX 2,1
110 * FX 3,0
120 A = INKEY(1)
130 IF A > 31 THEN VDU A AND 127
140 IF A = 41 THEN GOSUB 200
150 IF A = 13 OR A = 10 THEN VDU A
160 GOTO 40
200 A = 10 : VDU A
210 A = 13 : VDU A
220 RETURN
```

USING THE COMMODORE 64 *Continued from page 58*

(21 rows of 3 bytes [3 bytes = 24 bits]). The basic manual gives this information in greater detail, so refer to the relevant chapter for a fuller description.

Enough waffle — let's have a demonstration!

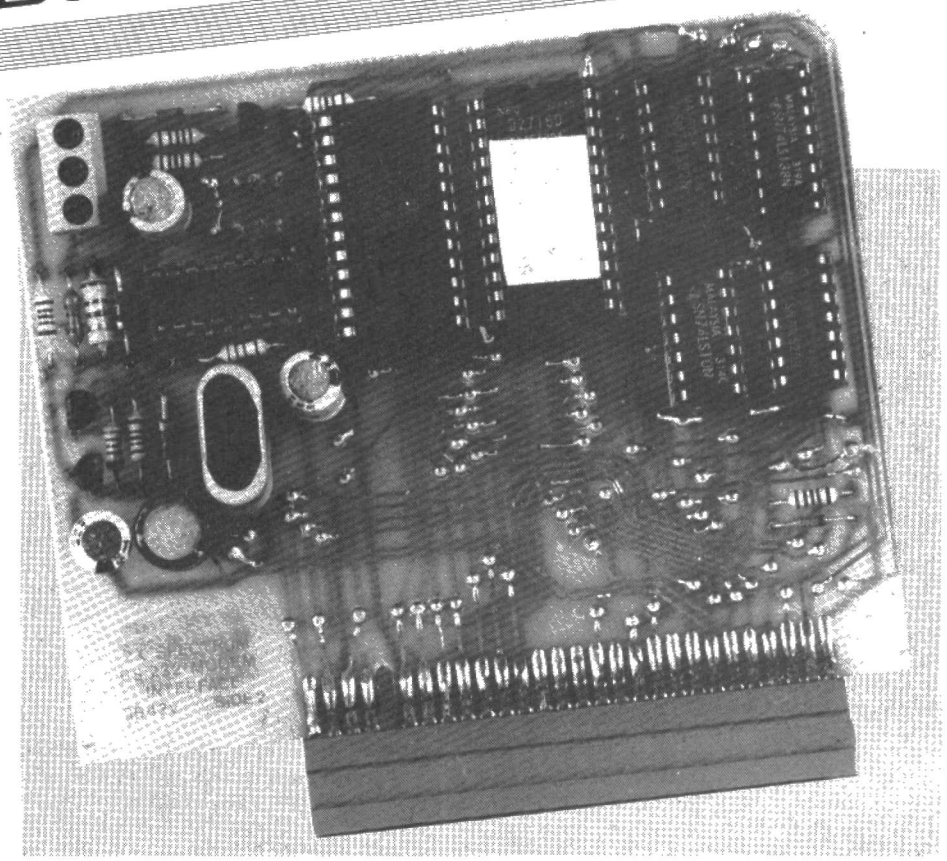
The following program sets up a sprite from basic, and then uses a machine code routine to handle the movement. The routine is continually recalled from basic, allowing you to add to the program which could form the basis for a game. A swan is set up using a sprite and swims backwards and forwards across the right hand side of the screen. This frees the rest of the screen for more action.

You will notice that two images are set up in memory for the swan, one facing right and one facing left. If I had not done this the poor swan would have had to swim backwards!

The assembly language routine is only shown for reference, the actual data for the machine code is included within the basic program.

```
SWAN    LDA   2046
        CMP   229
        BNE   RVSWAN
        LDA   53260
        CMP   46
        BEQ   RSPAT1
        INC   53260
        RTS
RVSWAN  LDA   53260
        CMP   0
        BEQ   RSPAT2
        DEC   53260
        RTS
RSPAT1  LDA   230
        STA   2046
        RTS
RSPAT2  LDA   229
        STA   2046
        RTS
```

ZX SPECTRUM RS232/MODEM INTERFACE



Our series of computer/modem interfaces continues with one for the Spectrum, which can be operated directly from BASIC, without typing or LOADing lengthy program listings. Access to (or exit from) the module may be initiated as required, either directly from switch-on or during a normal program run, without changing any previous contents of memory except the display file, and does not require RAM space to operate.

Interface

For computers to communicate with external sources suitable interfaces must be used. These must have the necessary facilities to enable compatibility with both devices and be under software control.

Transmitted or Received data is formatted as a character containing so many 'bits', and serialised for data transfer in a continuous stream. The speed of transfer is variable, but is usually standardised at 300 Bauds for modem/telephone links; higher Baud rates being required for higher transmission speeds.

Three wire links are used, one for transmitting data, one for receiving data, and a common 0V. Signal levels are to the RS232 standard of +12V amplitude at up to 20mA loads.

Circuit Description

Within the Spectrum ROM, before the character set, lies an unused area of memory between addresses 14446 and 15615. By disabling the ROM at the correct time this area is freed for use by the EPROM IC7 and ASCIA IC6 (A Synchronous Communications Interface Adaptor). ICs 1 to 4 perform the decoding necessary for memory mapping two areas. Addresses 14592 to 15584 are used for printing and operating subroutines, and addresses 15585 to 15615 are reserved for I/O scanning, word formatting, and data transfer. R1 and D1 supply the ROM CS disable pulse from IC3, also enabling IC7 during the correct read only address block. IC6 can be read or written to by the system within the address block determined by A5,6,7 and IC4 pin 11, but only four addresses are used, and these are detailed further on in the article.

IC5 is a fourteen stage ripple counter and clock oscillator running at 2.4576MHz, with C1, R10 and X1 determining the fundamental frequency, and this produces four divider outputs, shown in table 1.

Pin	Frequency	Baud	Link
6	19.2kHz	300	A
4	38.4kHz	600	B
5	76.8kHz	1200	C
7	153.6kHz	2400	D

Table 1.

Serial data output is from IC6 pin 6 and inverter IC2, whose normally low output holds TR2 in the 'off' state. TR1 does not conduct, due to lack of base drive current, and its collector sits at -10V potential, which appears at the RS232 output socket.

Pin 23 of the edge connector is notated -12V (page 160 of the user manual), when in fact it is derived from an internal oscillator, used for generating +12V and -5V supplies for the memory ICs, and takes the form of a 20kHz pulse waveform at approximately 12V. By connecting this signal via DC blocking capacitor C4 and referencing to ground via D4, a level shifted -12V signal is developed. This is rectified and smoothed by D3 and C5 to give approximately -10V DC at R5. TR1 switches between +12V and -10V during data transmission, producing the required RS232 levels to line. Incoming data is kept to a positive potential by D2, for switching TR3 and as a TTL input to pin 2 of IC6.

Module Operation

The EPROM IC6 holds 746 data bytes, most of which are used to display the MENU and WORD FORMAT options necessary for programming ASCIA IC6. Eight options are available for different

by Dave Goodman

- ★ **Connects the Spectrum to modems or other computers**
- ★ **RS232 compatible — 300/2400 Baud rates**
- ★ **Completely self-contained operating system — no programming, LOADing or SAVEing required!**
- ★ **Plugs into expansion socket or motherboard**

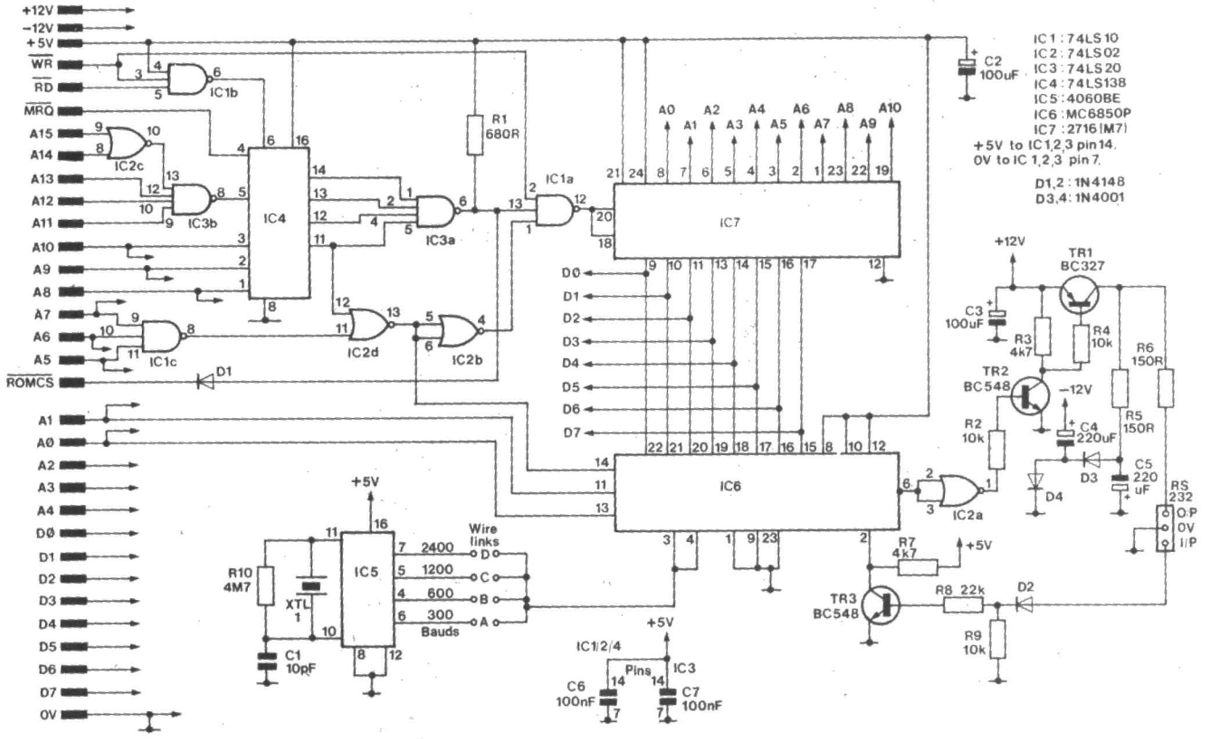


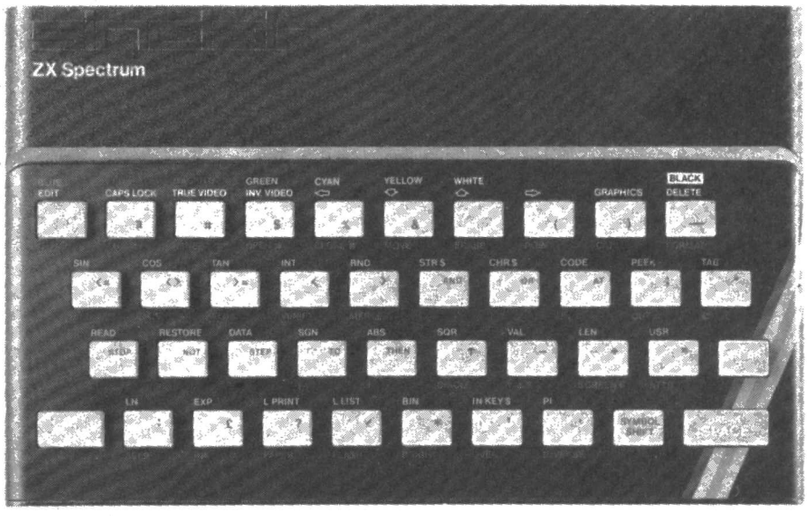
Figure 1. Circuit diagram.

word formats, setting total bits per character, odd, even, or no parity, and 1 or 2 stop bits. Master reset and clock divide ratios are also selected with these codes using data bits DØ to D4.

Within IC6 there are four registers accessible for use. Each register has a specific address and is either read or write in operation. See table 2 for definitions.

After control register has been set, the status register is examined to see if any data has arrived. If not, then the Spectrum keyboard is scanned for a key down. Various routines look for shifted or normal key operations, and also too many keys down before returning to the input status scanning routine. With the keys, say, 'CAPS SHIFT' and 'A', depressed, the formatted ASCII code '65' is transmitted once only, but if the key is held down for more than two seconds the character code will be repeatedly transmitted until released.

During repeat time the STATUS register is being scanned so that re-



Address	Register	Use
15612	Control (WR)	Reset, clock, and word format
15613	status (RD)	inspect incoming data
15614	Tx data (WR)	send 'Spectrum' codes to line
15615	Rx data (RD)	incoming data for printing

Table 2.

ceived data has priority over transmitted data. This ensures that characters are not lost when 'echo' is utilised. The STATUS register indicates parity error, overrun, frame error, whether the transmit register is empty, or if receive register is full. Control is directed according to these conditions so that when a character is correctly decoded it will be sent to the receive data register and read by the Spectrum CPU for printing, etc.

Specifications for the MC6850 ASCIAs are available from us if further information is required.

Construction

A double-sided PCB is used which requires 86 track through pins to be fitted. Insert these from side 2 into all holes marked with a circle, and carefully solder each pin to both sides of the board. Close track proximity requires very careful use of the soldering iron, otherwise bridging or shorting will occur, which can be difficult to trace and could result in damage being done to the Spectrum, so keep all soldering to a high standard.

This done, refer to the parts list and fit all ten resistors by bending each lead at right angles to the body and inserting in the correct position, flat to the board. Diodes D1 and 2 are fitted in the same way, except that each black band, or cathode, must align with the white band on the legend. Repeat for diodes D3 and D4. These should have a silver band.

Now solder the component leads onto the PCB and cut off the excess wire, before mounting capacitors C1 to 7. Note that C2 to 5 are electrolytic, and must be orientated for correct polarity; the PCB legend has a positive sign, denoting the lead NOT marked with a negative sign on the component body. Finally, insert Xtal 1 and the three way PC terminal, with the terminals facing outwards. Solder these components in place.

It is recommended that a suitable solvent, such as thinners, is used, together with a stiff paint brush, to remove flux from the PCB after the excess spills have been removed. Doing this will facilitate close inspection of joints and help to show up track shorts more clearly. Remember the importance of good workmanship whilst constructing this project, as, although there are only a few components, mistakes can easily be made which can damage the Spectrum; so check your work thoroughly.

Testing

Connect the module either directly into a motherboard if you have one, or solder a 2x28 way 0.1in socket to the edge connector (see parts list) and plug into the rear expansion port. For the moment, fit IC3 only. A voltmeter or oscilloscope will be required for making a few checks around the circuit, and the

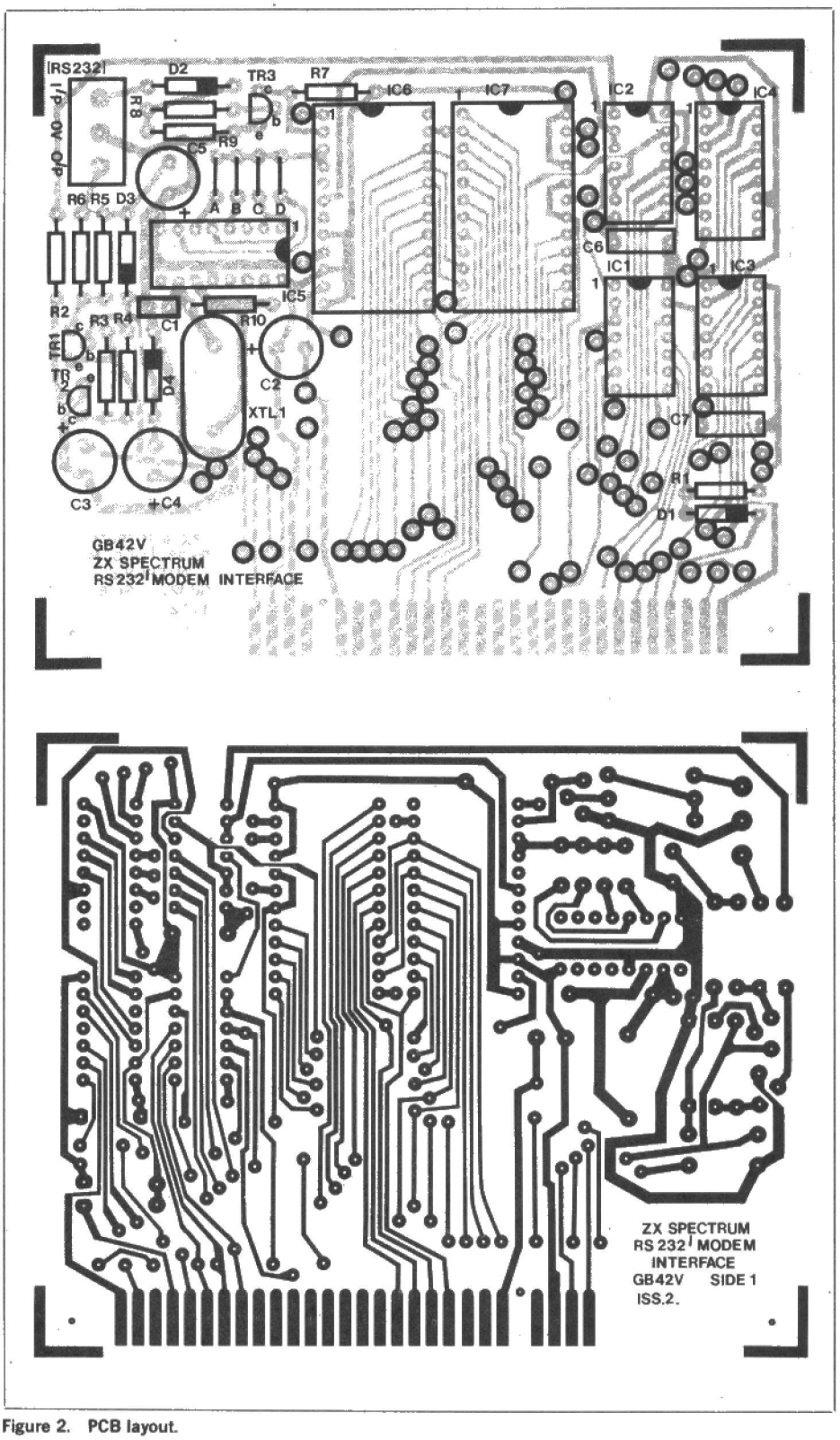


Figure 2. PCB layout.

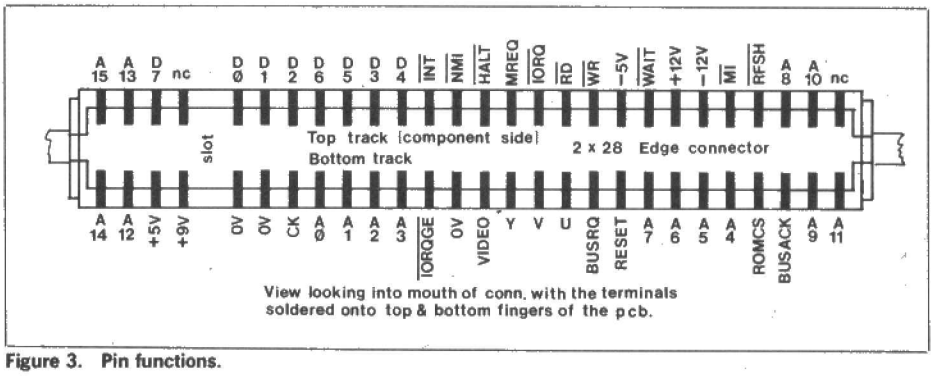
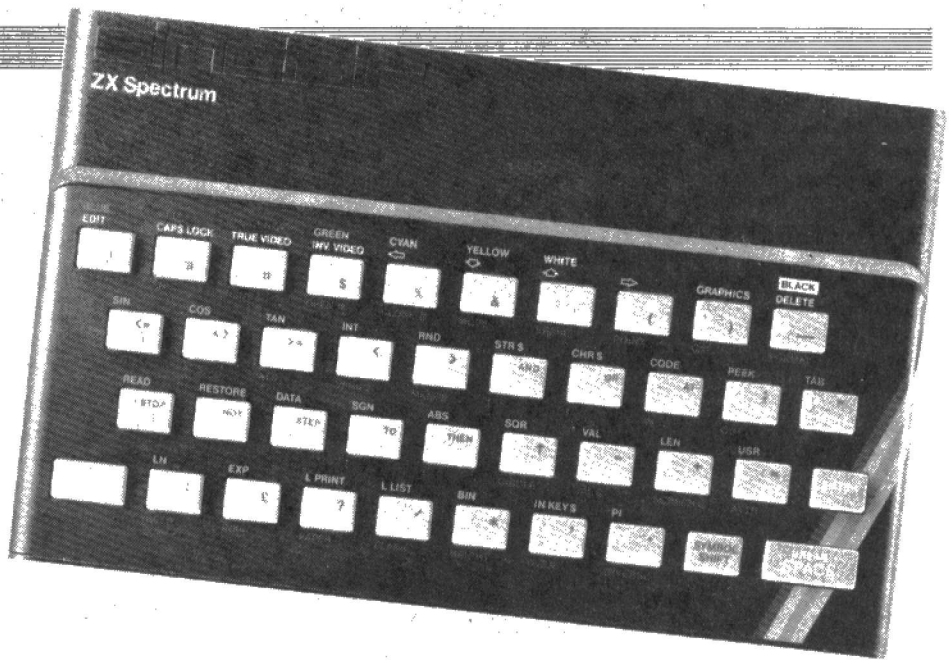

A15 A13 D7 nc
D0 D1 D2 D6 D5 D3 D4 INT NMI HALT MREQ IORQ RD WR -5V WAIT +12V -12V MI RFSH A8 A10 nc
slot
Top track (component side)
Bottom track
2 x 28 Edge connector
A14 A12 +5V +9V
0V 0V CK A0 A1 A2 A3 IORQGE 0V VIDEO Y V U BUSRQ RESET A7 A6 A5 A4 ROMCS BUSACK A9 A11
View looking into mouth of conn. with the terminals soldered onto top & bottom fingers of the pcb.

Figure 3. Pin functions.



centre terminal of the RS232 connector socket can be used as an 0V reference point.

With TV and PSU connected, switch on and check for usual display and keyboard operation. Any problem here will appear either as vertical lining or a permanent black display, in which case you should switch off immediately and remove the module. If all is well, you should check for:

1. +4.5V between 0V and IC4 pin 16
2. +0.2V between 0V and the junction of D1 and R1
3. +11 to +12V between 0V and R3/TR1 emitter
4. -11 to -12V between 0V and the RS232 output socket

Switch off, remove the module, and fit link A. The remaining six ICs can now be fitted and the module reinserted. Switch on again, and type:

10 POKE 15612,3:POKE 15612,1
20 POKE 15614,85:GOTO 20

Recheck the RS232 output for -11V and run the program. Line 20 continually transmits ASCII code 85, or 'U' which has an even mark to space ratio. The average output reading will therefore be halfway between -11V and +11V, i.e. approximately 0V. Break the program and check that the reading returns to -11V again. This test proves that address decoding logic, ASCIA, and output converter stages are functioning correctly.

Remove the voltmeter, connect the RS232 output and input terminals together with a short length of wire and type RAND USR 14592, then ENTER, to access the module. A MENU will be displayed listing word format codes a to h and instructions showing how to return either to BASIC or MENU. All entries are direct from the key concerned, without using ENTER, and, for letters only, normal lower case is transmitted. CAPS SHIFT is used for changing from lower to upper case, but will not function with numbers 1 to 0, so that CAPS LOCK, CURSOR, and DELETE are not available. All red shift symbols can be used with the SYMBOL SHIFT key, as can the ENTER key, remembering that shifted A (stop) will display the MENU. Pressing both CAPS and SYMBOL SHIFT keys allows a return to BASIC, upon which the module is no longer effective until called by the USR instruction.

Press both SHIFT keys to prove that this is so, and the O.K. prompt will appear. Type RAND USR 14592 again for the MENU and select WORD FORMAT code f. You will see that all single keys above H are inoperative and only A to H are recognised. The 'DATA?' prompt is waiting for incoming information for printing, so press the A key. Lower case a will appear at the start of a new line (automatic carriage return), now press CAPS SHIFT and A. Upper case A will be printed adjacent to the last character. Hold the A key down and printing will repeat, filling the line with 32 characters before auto-scrolling. Clear the screen by holding the ENTER (carriage return) key down, then select STOP to return to MENU.

The Module In Use

The most common word format used is f, or 8 bits per character with one stop bit. The format is applicable to our Maptel A and B systems, but other systems could require different format codes. If data is being received before the module is selected the characters may be unsynchronised, and garbage will be printed, so have the module functioning before data arrives, to avoid this occurring. Baud speeds up to 2.4KB are selected by fitting a link in the appropriate position.

Connected for 300 Bauds, which is the CCITT standard for use over telephone lines, it will match Maptel and also our Modem.

In normal use, transmitted data will not be displayed unless peripheral equipment connected to the interface has an 'echo' facility, which sends data back on receipt of incoming data. Shorting both transmit and receive lines to simulate echo may cause problems when using modem systems, and is recommended for test purposes only. Finally, the EPROM IC7 has 256 spare bytes available at the end of the instruction set which have been left high or FF. Additional instructions can be placed here and called as a machine code routine, providing you have the necessary equipment for doing this.

The first spare address is:
Spectrum — 15338
EPROM — 1002

ZX SPECTRUM RS232/MODEM INTERFACE PARTS LIST

Resistors — All 0.4W 1% metal film unless specified.

R1	680R		(M680R)
R2,4,9	10k	3 off	(M10K)
R3,7	4k7	2 off	(M4K7)
R5	150R (½W carbon)		(S150R)
R6	150R		(M150R)
R8	22k		(M22K)
R10	4M7 carbon film ½W 5%		(B4M7)

Capacitors

C1	10pF ceramic		(WX44X)
C2,3	100uF 25V P.C. electrolytic	2 off	(FF11M)
C4,5	220uF 16V P.C. electrolytic	2 off	(FF13P)
C6,7	100nF disc	2 off	(BX03D)

Semiconductors

D1,2	IN4148	2 off	(QL80B)
D3,4	IN4001	2 off	(QL73Q)
TR1	BC327		(QB66W)
TR2,3	BC548	2 off	(QB73Q)
IC1	74LS10		(YF08J)
IC2	74LS02		(YF02C)
IC3	74LS20		(YF14Q)
IC4	74LS138		(YF53H)
IC5	4060BE		(QW40T)
IC6	MC6850P		(WQ48C)
IC7	2716/M7		(QY57M)

Miscellaneous

XTL1	MP crystal 2.4576 MHz		(FY81C)
	P.C. Board		(GB42V)
	3 way P.C. terminal		(RK72P)
	Trackpins	2 pkts	(FL82D)
	D.I.L. socket 24 pin	2 off	(BL20W)
	D.I.L. socket 16 pin	2 off	(BL19V)
	D.I.L. socket 14 pin	3 off	(BL18U)

Optional part

	0.1 in 2 x 28 PC Edgecon		(FG23A)

A complete kit of all parts, excluding FG23A, is available.
Order As LK21X (Spectrum RS232 Kit) Price £17.95

FIRST BASE *Continued from Page 47*

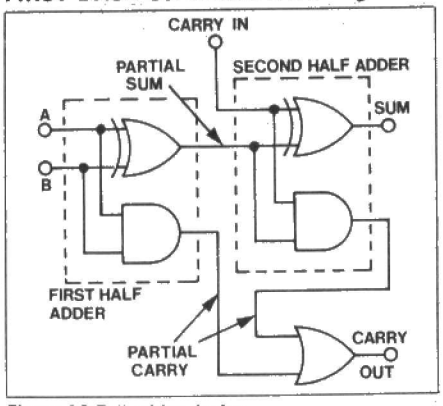


Figure 12. Full adder design

there may be 16 address lines, each of which is set to either 1 or 0 according to the specific address which the micro-processor wishes to access. The address is set in response to the requirements of the controlling program or soft-ware, and the logic must ensure that only one device is enabled if data bus contention is not to arise. With 16 address lines there are 65,536 possible unique addresses, corresponding to the locations in the memory map of the system. There are a number of logic devices which have been specially devised for address decoding, but we will consider a smaller problem using devices already described.

In some systems, the lower eight address lines are used by the micro-processor for a special purpose, that of addressing input or output devices which allow information to be fed between the processor and the 'outside world'. With only eight lines the number of possible addresses is reduced to 256, which helps to bring the problem down to more manageable proportions. What is needed, then, is a logical 'black box' into which may be sent the eight address lines along with

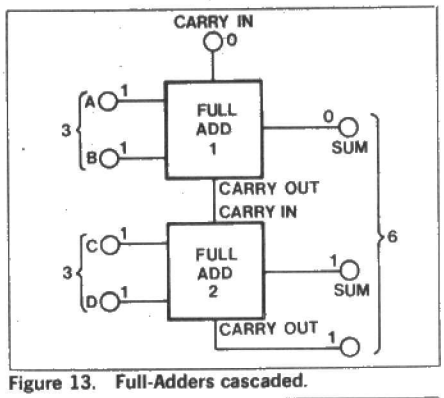


Figure 13. Full-Adders cascaded.

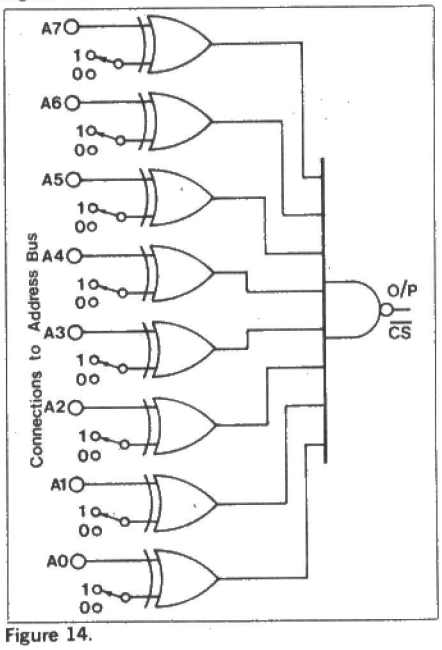


Figure 14.

signals to set a certain address, and from which emerges one line carrying the logic signal to select the particular device being addressed.

One solution to this problem is given in Figure 14 and again this may be breadboarded to see how it works. One input of the EX-NOR gates is connected to the address bus, and the other used to select the address of the device. The output of each EX-NOR gate is then NANDed, so that the final output goes low when the appropriate address appears on the address bus. This low signal could be connected to the 'chip select', (CS) pin of the chosen device or combined with other control bus signals for further decoding. Suppose the address of the input/output device corresponds to the following bit pattern:-

Most Significant Bit Least Significant Bit
(MSB) 1 1 0 1 0 0 1 1 (LSB)

If this pattern is set on the inputs to the EX-NOR gates then all the outputs from them will go high when the two bit patterns coincide. This in turn will set the inputs to the 8-input NAND gate all high, which is the only condition for the output to go low.

The required address may be fixed in a practical application by 'hard-wiring' the selecting inputs to the desired pattern; alternatively, the inputs may be connected via DIP switches, so that the address may be changed by altering the position of the switches.

A more convenient way of describing a bit pattern, such as the one in the above example, is to use the hexadecimal system. We shall be looking at this in more detail next time for any readers who are not familiar with the system. It will also be useful when dealing with the other main group of TTL devices, viz. those concerned with Sequential logic, which we shall also start to have a look at in the next article in the series.

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